10 Acoustic Assessment

Introduction

10.1 This chapter contains an assessment of the acoustic impact of the proposed Upper Ogmore Wind Farm (hereafter referred to as the Proposed Development). The report assesses wind farm operational noise and construction noise at the nearest residential properties.

10.2 This chapter is supported by the following:

- Figure 10.1 – Predicted Noise Footprint due to the Proposed Upper Ogmore Wind Farm;
- Figure 10.2 – Predicted Cumulative Noise Footprint;
- Technical Appendix 10.1 – Assessment of Energy Storage Facility;
- Technical Appendix 10.2 – Scope of Assessment;
- Technical Appendix 10.3 – Calculating Standardised Wind Speed;
- Technical Appendix 10.4 – Propagation Height & Valley Effect;
- Technical Appendix 10.5 – Background Noise Survey Photos;
- Technical Appendix 10.6 – Instrumentation Records;
- Technical Appendix 10.7 – Charts; and
- Technical Appendix 10.8 – Suggested Planning Conditions.
- Glossary

10.3 Figures and Technical Appendices are referenced in the text where relevant.

Statement of Authority

10.4 This assessment has been undertaken by RES, with at least one in-house Member of the Institute of Acoustics involved in its production. RES has undertaken acoustic impact assessments in every single one of its UK wind farm development applications since 2000. RES has also carried out noise assessments and reported to several local planning authorities on operational wind energy projects including taking measurements on newly constructed wind farms to ensure compliance with planning conditions.

10.5 Additionally, RES has been project co-ordinator for several Joule[1] projects, leading European research into wind turbine noise, was involved in producing the guideline

[1] DGXII European Commission funded projects in the field of Research and Technological Development in non-nuclear energy

'The Assessment and Rating of Noise from Wind Farms'[2] for the DTI in 1996, acted as peer reviewer for the 'Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'[3], and contributed to the RenewableUK work on Amplitude Modulation[4]. Publications include:

- 'An Investigation of Blade Swish from Wind Turbines', P Dunbabin, Proceedings of the 1996 International Congress on Noise Control Engineering (Internoise '96), 30 July – 2 August 1996, Book 1, pp 463 – 469;
- 'An Automated System for Wind Turbine Tonal Assessment', R Ruffle, Proceedings of the 1996 International Congress on Noise Control Engineering (Internoise '96), 30 July – 2 August 1996, Book 6, pp 2997 – 3002;
- 'Wind Turbine Measurements for Noise Source Identification', ETSU W/13/003914/00.REP, 1999, Dr P Dunbabin, RES et al;
- 'A Critical Appraisal of Wind Farm Noise Propagation', ETSU W/13/00385/REP, 2000 Dr J Bass, RES;
- 'Aerodynamic Noise Reduction for Variable Speed Turbines', ETSU/W/45/00504/REP, 2000, Dr P Dunbabin, RES;
- 'Fundamental research in amplitude modulation - a project by RenewableUK', Dr J Bass et al, Fourth International Meeting on Wind Turbine Noise, Rome, April 2011;
- 'Investigation of the 'Den Brook' Amplitude Modulation methodology for wind turbine noise', Dr J Bass, Acoustics Bulletin Vol 36 No 6 November/December 2011;
- 'How does noise influence the design of a wind farm?', Dr M Cassidy, Fifth International Conference on Wind Turbine Noise, Denver, 2013;
- 'Propagation of Noise from Wind Farms According to the Good Practice Guide', A Birchby, Sixth International Conference on Wind Turbine Noise, Glasgow, 2015; and
- 'Addressing the Issue of Amplitude Modulation', Dr M Cassidy, Sixth International Conference on Wind Turbine Noise, Glasgow, 2015;
- 'A Method for Rating Amplitude Modulation in Wind Turbine Noise', Institute of Acoustics Noise Working Group, August 2016; and

[2] 'The Assessment and Rating of Noise from Wind Farms', The Working Group on Noise from Wind Turbines, ETSU Report for the DTI, ETSU-R-97

[3] 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise', Institute of Acoustics, May 2013

[4] 'Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effects', RenewableUK, 2013

- 'Pre-construction Site Prediction Tool for Wind Farm AM – Do We Now Know Enough?', A Birchby, Seventh International Conference on Wind Turbine Noise, Rotterdam, 2017.

Wind Turbine Noise

10.6 In the context of other sources of environmental noise, the noise levels produced by wind turbines are generally low and have greater dependence upon wind speed. The combination of these two factors implies that a degree of masking would often be provided by background noise.

10.7 As described by the Planning Policy Wales Technical Advice Note 8[5]:

"There are two quite distinct types of noise source within a wind turbine - the mechanical noise produced by the gearbox, generator and other parts of the drive train and the aerodynamic noise produced by the passage of the blades through the air. There has been a significant reduction in mechanical noise since the early 1990's so the latest generation of wind turbines are much quieter than those first installed in Wales".

Construction Noise

10.8 The sources of construction noise, which are temporary, would vary both in location and duration as the different elements of the Proposed Development are constructed and would arise primarily through the operation of large items of plant.

10.9 Noise would also arise due to the temporary increase in construction traffic near the site. This level would also depend on the particular construction phase of the Proposed Development.

10.10 Blasting might be required in order to extract material from the proposed borrow pits. Vibration and air overpressure due to blasting could therefore arise at periods during construction.

Scope of Assessment

10.11 Noise can have an effect on the environment and on the quality of life enjoyed by individuals and communities. The effect of noise, both in the construction and operational phase, is therefore a material consideration in the determination of planning applications.

10.12 Whilst noise would also arise during decommissioning of the Proposed Development (through turbine deconstruction and breaking of the exposed part of the concrete bases) this is not discussed separately as noise levels resulting from it are expected to be lower than those during construction due to the number and type of activities

[5] 'Planning for Renewable Energy', Planning Policy Wales Technical Advice Note 8, Welsh Assembly Government, July 2005

involved. The impact of decommissioning can therefore be considered in light of the conclusions of the construction noise assessment.

Operational Noise

10.13 The main focus of the assessment of operational noise presented here is based on the most relevant type of noise emission for modern wind turbines: aerodynamic noise, which is broadband in nature. Mechanical noise, which can be tonal in nature, is also considered albeit less relevant to modern wind turbines. Implicitly incorporated within this assessment is the normal character of the noise associated with wind turbines (commonly referred to as 'blade swish') and consideration of a range of noise frequencies, including low frequencies.

10.14 An acoustic assessment considering the operation of the proposed Energy Storage Facility can be found in **Technical Appendix 10.1**.

10.15 Low frequency content of the noise from wind farms shall be considered through the use of octave band specific noise emission and propagation modelling, however it is considered that a specific and targeted assessment on the low frequency content of noise emissions from the Proposed Development is unjustified. Details for scoping out low frequency noise from the acoustic assessment, as well as infrasound, sleep disturbance, vibration, amplitude modulation and wind turbine syndrome can be found in **Technical Appendix 10.2**.

10.16 A summary of the findings of a comprehensive study into wind turbine noise and associated health effects can be found in **Technical Appendix 10.2**.

Construction Noise

10.17 The acoustic impact assessment of construction noise from the Proposed Development presented here is based on RES's experience of constructing wind farms and calculated for the operation of the primary large items of construction equipment associated with the noisiest activities. Additionally, consideration is given to the increased noise levels due to increased traffic flows during the construction phase to and from the site.

10.18 An assessment of the level of vibration at nearby properties due to blasting to release material from the proposed borrow pits shall be undertaken. Air overpressure due to blasting cannot be reliably predicted so is not assessed here although steps to limit any resulting impact through appropriate blast design can be adopted.

Legislative Framework & Guidance

Operational Noise

10.19 Within Wales, noise is defined within the planning context by Planning Policy Wales[6] which states that:

"Noise can affect people's health and well-being and have a direct impact on wildlife and local amenity. Noise levels provide an indicator of local environmental quality. The objective of a policy for noise is to minimise emissions and reduce ambient noise levels to an acceptable standard."

10.20 Planning Policy Wales refers to Noise Action Plans which aim to *"prevent and reduce environmental noise where necessary and preserve environmental noise quality where it is good"*. The current Noise Action Plan[7] identifies the report 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97) as the guidelines for the assessment of wind turbine noise and outlines the findings of a number of subsequent studies into the applicability and implementation of these guidelines.

10.21 Planning Policy Wales also states that in some circumstances it will be necessary for a technical assessment to be provided, at which point it references Technical Advice Note 11: Noise[8] which:

"…provides advice on how the planning system can be used to minimise the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business."

10.22 Technical Advice Note 11: Noise refers to detailed guidance on noise from wind turbines being contained in Technical Advice Note 8: Planning for Renewable Energy[5].

10.23 In relation to noise from wind farms Technical Advice Note 8: Planning for Renewable Energy states:

"The report 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97), describes a framework for the measurement of wind farm noise and gives indicative noise levels calculated 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 planning authorities. The report presents the findings of a cross-interest Noise Working Group and makes a series of recommendations that can be regarded as relevant guidance on good practice."

[6] 'Planning Policy Wales', Edition 9, Welsh Government, November 2016
[7] 'A noise action plan for Wales 2013-2018', Welsh Government, December 2013
[8] 'Planning Guidance (Wales), Technical Advice Note 11: Noise', Welsh Assembly Government, October 1997

10.24 It is therefore considered that the use of ETSU-R-97 for the assessment of wind farm noise fulfils the requirements of Technical Advice Note 11: Noise and Planning Policy Wales.

10.25 The methodology described in ETSU-R-97 was developed by a working group comprised of a cross section of interested persons including, amongst others, environmental health officers, wind farm operators and independent acoustic experts.

10.26 ETSU-R-97 makes it clear from the outset that any noise restrictions placed on a wind farm must balance the local environmental impact against the national and global benefits that arise through the development of renewable energy resources. The principle of balancing development needs against protection of amenity may be considered common to any type of noise control guidance.

10.27 The basic aim of ETSU-R-97, in arriving at the recommendations contained within the report, is the intention to provide:

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

10.28 An article published in the Institute of Acoustics Bulletin (IoA Bulletin) Vol. 34 No. 2, March/April 2009[9], recommends a methodology for addressing issues not made explicit by, or outside the scope of, ETSU-R-97, such as in relation to wind shear or noise propagation modelling. Whilst this article does not represent formal legislation or guidance it was authored by a group of independent acousticians experienced in wind farm noise issues who have undertaken work on behalf of wind farm developers, local planning authorities and third parties and as such is a good indicator of best practice techniques. The assessment presented herein adopts the recommendations made within this article.

10.29 A Good Practice Guide (IoA GPG) on the application of ETSU-R-97 for the assessment and rating of wind turbine noise[3], issued by the Institute of Acoustics in May 2013 and endorsed by the Northern Ireland Executive along with the governments in England, Scotland and Wales, provides guidance on all aspects of the use of ETSU-R-97 and reaffirms the recommendations of the Acoustics Bulletin article with regard to propagation modelling and wind shear. The assessment presented herein adopts the recommendations of the Good Practice Guide as agreed with Bridgend County Borough Council.

10.30 Supplementary guidance notes were published by the Institute of Acoustics in July and September 2014, and these provide further details on specific areas of the IoA

[9] 'Prediction and Assessment of Wind Turbine Noise', Bowdler et al, Acoustics Bulletin Vol 34 No 2 March/April 2009

GPG[10]. The assessment presented herein adopts the recommendations made within these supplementary guidance notes.

10.31 ETSU-R-97 has been applied at the vast majority of wind farms currently operating in the UK and provides a robust basis for assessing the noise impact of a wind farm when used in accordance with the IoA GPG. It is the only relevant guidance referenced in Welsh planning policy for rating and assessing operational noise. Based on planning policy and guidance, as outlined above, a wind farm which can operate within noise limits derived according to ETSU-R-97 shall be considered acceptable. This approach has been agreed with Bridgend County Borough Council.

Construction Noise

10.32 In Wales, advice on construction noise assessment is referred to in 'Technical Advice Note 11: Noise' which states[8]:

"Detailed guidance on assessing noise from construction sites can be found in BS 5228, parts 1-4. In particular, Part 1: 1984, 'Code of practice for basic information and procedures for noise control" describes a method for predicting noise from construction sites as well as giving general advice'.

10.33 Since the 1984 version has been superseded by BS 5228-1:2009 'Code of practice for noise and vibration control on construction and open sites - Part 1: Noise'[11], this has been identified as being the appropriate source of guidance on appropriate methods for minimising noise from construction activities, and is adopted herein.

10.34 The Control of Pollution Act 1974 provides information on the need for ensuring that the best practicable means are employed to minimise noise[12].

10.35 BS 5228-2:2009 'Code of practice for noise and vibration control on construction and open sites - Part 2: Vibration'[13], provides a method for predicting vibration levels which has been adopted in this assessment.

10.36 BS 6472-2:2008 'Guide to evaluation of human exposure to vibration in buildings - Part 2: Blast-induced vibration'[14] has been used to set criteria for satisfactory magnitudes of vibration at nearby residential properties to ensure compliance with respect to human response.

Consultation

10.37 Details of the consultation undertaken are outlined in **Table 10.1**.

[10] 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise - Supplementary Guidance Notes', Institute of Acoustics, July & September 2014

[11] 'Code of Practice for Noise and vibration control on construction and open sites - Part 1: Noise', British Standards Institution, BS 5228-1:2009

[12] 'Control of Pollution Act', Control of Pollution Act, published by Her Majesty's Stationary Office, 1974

[13] 'Code of Practice for Noise and vibration control on construction and open sites - Part 2: Vibration', British Standards Institution, BS 5228-2:2009

[14] 'Guide to evaluation of human exposure to vibration in buildings. Blast-induced vibration', BS 6472-2:2008

Table 10.1: Acoustic Assessment Consultation

Consultees	Date of Consultation	Nature and Purpose of Consultation
Bridgend County Borough Council	01/09/2016	Report "Planned Acoustic Assessment at the Proposed Upper Ogmore Wind Farm" (ref. 02959-000836) sent to EHO, via email outlining methodology and proposed monitoring locations.
Bridgend County Borough Council	12/09/2016	Email from EHO at Bridgend County Borough Council proposing a number of items to be considered and accepting the proposed methodology.
Bridgend County Borough Council	12/09/2016	Email to the EHO at Bridgend County Borough Council notifying them that the planned background noise survey due to be carried out in October 2016 is postponed until further notice.
Bridgend County Borough Council	01/11/2017	Email to EHO at Bridgend County Borough Council notifying them that the background noise survey is due to commence after mast erection week commencing 20th November 2017.
Bridgend County Borough Council	23/11/2017	Email from EHO at Bridgend County Borough Council noting that the effect of the existing Pant Y Wal wind farm (plus extension), in addition to the operational Llynfi Afan wind farm, on the background noise measurements should also be minimised.
Public	28-29/11/17	Public exhibitions held.
Bridgend County Borough Council	13/02/2018	Arranging to meet on site to setup noise meters on 15/02/2018.
Bridgend County Borough Council	20/02/2018	Report "Noise Survey Locations for the Proposed Upper Ogmore Wind Farm" (ref. 02959-001442) sent to EHO detailing final installed monitoring locations.
Bridgend County Borough Council	27/02/2018	Further detail about sites for consideration in cumulative assessment provided by EHO including conditioned limits.
The Planning Inspectorate	March 2018	Scoping report submitted.
Bridgend County Borough Council	29/03/2018	Call to discuss movement of meter from Nantymoel Farm to Ty-Talgarth.

Consultees	Date of Consultation	Nature and Purpose of Consultation
Bridgend County Borough Council	27/04/2018	Information on limits for Pant Y Wal, Pant Y Wal Extension & Fforch Nest for use in cumulative assessment provided by EHO.
The Planning Inspectorate	May 2018	Scoping direction received.
Bridgend County Borough Council	23/05/2018	Response to query regarding applicable limits for Llynfi Afan scheme.
Bridgend County Borough Council	07/06/2018	Further confirmation of limits applicable to Llynfi Afan scheme along with additional information on conditioned limits for Pant Y Wal, Pant Y Wal Extension & Fforch Nest.
Public	04-05/09/18	Public exhibitions held.

Methodology

Operational Noise

10.38 To ensure adequate assessment of the potential impacts of the operational noise from the Proposed Development the following steps have been taken, in accordance with relevant guidance detailed above:

- The baseline noise conditions at each of the nearest residential properties to the Proposed Development are established by way of representative background noise surveys;
- The noise levels at the nearest residential properties due to the operation of the Proposed Development are predicted using a sound propagation model considering: the locations of the wind turbines; the intervening terrain; and the likely noise emission characteristics of the wind turbines;
- With due regard to relevant guidance or regulations the acoustic assessment criteria are derived; and
- The evaluation of the acoustic impact is undertaken by comparing the predicted noise levels with the assessment criteria.

Establishing Baseline Conditions

10.39 Similar to other assessments of noise impacts (most notably BS 4142, 'The Method for Rating Industrial Noise affecting Mixed Residential and Industrial Areas' which ETSU-R-97 identifies as forming the basis of its recommendations), the ETSU-R-97 methodology requires the comparison of predicted noise levels due to turbine

emissions (which vary with hub height wind speed) with noise limits based upon the noise levels already existing under those same conditions (i.e. the baseline conditions).

10.40 Since background noise levels depend upon wind speed, as indeed do wind turbine noise emissions, it is important when making reference measurements to put them in that context. Thus, the assessment of background noise levels at potentially sensitive residential properties requires the measurement of not only noise levels, but concurrent wind conditions, covering a representative range of wind speeds. These wind measurements are made at the site rather than at the residential properties, since it is this wind speed that would subsequently govern the wind farm's noise generation. Often the residential properties themselves will be sheltered from the wind and may consequently have relatively low background noise levels.

10.41 To establish the baseline conditions, sound level meters and associated apparatus are set-up to record the required acoustic information at a selection of the nearest residential properties geographically spread around the site, agreed with Bridgend County Borough Council, which are likely to be representative of other residential properties in the locale.

10.42 Wind speed and direction are recorded as 10 minute averages for the same period as for the noise measurements, and are synchronised with the acoustic data to allow correlations to be established. The wind speed that is adopted for use is the same wind speed as that which drives the turbine noise levels.

10.43 The adoption of this wind speed was recommended within the article published in the IoA Bulletin and the subsequent IoA GPG. The methodology used to calculate standardised 10 m wind speed is described in **Technical Appendix 10.3**.

10.44 Prior to establishing the baseline conditions the acoustic data is filtered as follows:

- For each background noise measurement location, the measured noise data is divided into two sets, as specified by ETSU-R-97 and shown in **Table 10.2**:

Table 10.2: Definition of Time of Day Periods

Time of Day	Definition
Quiet daytime	18:00 - 23:00 every day 13:00 - 18:00 Saturday 07:00 - 18:00 Sunday
Night-time	23:00 - 07:00 every day

- Rainfall affected data is systematically removed from the acoustic data set. To facilitate this, a rain gauge is deployed at the site to record 10 minute rainfall data and identify potentially affected noise data. Both the 10 minute period containing the bucket tip and the preceding 10 minute period are removed from the dataset as recommended in the IoA GPG to account for the time it takes for the rain gauge tipping bucket to fill.

- Periods of measured background noise data thought to be affected by extraneous, i.e. non-typical, noise sources are identified and removed from the data set. Whilst some 'extraneous' data may actually be real, it tends to bias any trend lines upwards so is removed as a conservative measure.
- In practice this means close inspection of the measured background noise levels, comparison with concurrent data measured at nearby locations and consideration of both directional and temporal variation.

Modelling Noise Propagation

10.45 Whilst there are several sound propagation models available, the ISO 9613 Part 2 model has been used[15], this being identified as most appropriate for use in such rural sites[16]. The specific interpretation of the ISO 9613 Part 2 propagation methodology recommended in the aforementioned IoA Bulletin and the subsequent IoA GPG has been employed.

10.46 To make noise predictions it is assumed that:

- the turbines are identical;
- the turbines radiate noise at the power specified in this report;
- each turbine can be modelled as a point source at hub-height;
- each residential property is assigned a reference height to simulate the presence of an observer.

10.47 The sound propagation model takes account of attenuation due to geometric spreading and atmospheric absorption. The assumed temperature and relative humidity are 10 ˚C and 70 % respectively, as recommended in the IoA Bulletin and IoA GPG. Ground effects are also taken into account by the propagation model with a ground factor of 0.5 and a receiver height of 4 m used as recommended in the IoA Bulletin and IoA GPG.

10.48 The barrier attenuations predicted by ISO 9613 Part 2 have been shown to be significantly greater than those measured in practice under downwind conditions[16]. Therefore, barrier attenuation according to the ISO 9613 Part 2 method has been discounted. In lieu of this, where there is no direct line of sight between the residential property in question and any part of the wind turbine, 2 dB attenuation has been assumed as recommended in the IoA Bulletin and the IoA GPG.

10.49 Additionally, verification studies have also shown that ISO 9613 Part 2 tends to slightly underestimate noise levels at nearby dwellings in certain exceptional cases, notably in a valley type environment where the ground drops off between source and receiver[16]. In these instances an addition of 3 dB(A) has been applied to the resulting overall A-weighted noise level as recommended by the IoA GPG. Further detail is provided in **Technical Appendix 10.4**.

10.50 To generate the ground cross sections between each turbine and each dwelling necessary for reliable propagation modelling, ground contours at 5 m intervals for the area of interest have been generated from 50 m grid resolution digital terrain data.

[15] 'Acoustics - Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation', International Organisation for Standardisation, ISO 9613-2:1996

[16] 'A Critical Appraisal of Wind Farm Noise Propagation', ETSU Report W/13/00385/REP, 2000

10.51 The predicted noise levels are calculated as L_{Aeq} noise levels and changed to the L_{A90} descriptor (to allow comparisons to be made) by subtraction of 2 dB, as specified by ETSU-R-97.

10.52 It has been shown by measurement based verification studies that the ISO 9613 Part 2 model is capable of providing a high degree of accuracy when calculating far field noise levels from elevated sources when the exceptional cases identified above are corrected for[16]. Examples of conservative assumptions modelled which increase the likelihood of the calculated noise levels being an overestimate are:

- properties are assumed to be downwind of all noise sources simultaneously and at all times. In reality, this is not the case and additional attenuation would be expected when a property is upwind or crosswind of the proposed wind turbines;
- although, in reality, the ground is predominantly porous (acoustically absorptive) it has been modelled as 'mixed', i.e. a combination of hard and porous, corresponding to a ground absorption coefficient of 0.5 as recommended by the IoA Bulletin and IoA GPG;
- receiver heights are modelled at 4 m above local ground level, which equates roughly to first floor window level, as recommended by the IoA Bulletin and IoA GPG. This results in a predicted noise level anything up to 2 dB(A) higher than at the typical human ear height of 1.2-1.8 m;
- trees and other non-terrain shielding effects have not been considered;
- an allowance for measurement uncertainty has been included in the sound power levels for the presented turbine.

Operational Noise Impact Criteria

10.53 Noise is measured in decibels (dB) which is a measure of the sound pressure level, i.e. the magnitude of the pressure variations in the air. Measurements of environmental noise are usually made in dB(A) which includes a correction for the sensitivity of the human ear.

10.54 ETSU-R-97 seeks to protect the internal and external amenity of wind farm neighbours by defining acceptable limits for operational noise from wind turbines. The test applied to operational noise is whether or not the noise levels produced by the combined operation of the wind turbines lie below noise limits derived in accordance with ETSU-R-97 at nearby residential properties.

10.55 Whilst ETSU-R-97 presents a comprehensive and detailed assessment methodology for wind farm noise, it also provides a simplified methodology:

"if the noise is limited to an $L_{A90,10min}$ of 35 dB(A) up to wind speeds of 10 m/s at 10 m height, then these conditions alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary".

10.56 In the detailed methodology, ETSU-R-97 states that different limits should be applied during daytime and night-time periods. The daytime limits, derived from the background noise levels measured during quiet daytime periods, are intended to preserve outdoor amenity, while the night-time limits are intended to prevent sleep disturbance. The general principle is that the noise limits should be based on existing background noise levels, except for low background noise levels, in which case a fixed limit may be applied. The suggested limits are given below, where L_B is the background $L_{A90,10min}$ and is a function of wind speed. During daytime periods and at low background noise levels, a lower fixed limit of 35-40 dB(A) is applicable. The exact value is dependent upon a number of factors: the number of nearby dwellings, the effect of the noise limits on energy produced, and the duration and level of exposure.

Table 10.3: Permissible Noise Level Criteria

Time of Day	Permissible Noise Level
Daytime	• 35-40 dB(A) for L_B less than 30-35 dB(A) • L_B + 5 dB, for L_B greater than 30-35 dB(A)
Night-time	• 43 dB(A) for L_B less than 38 dB(A) • L_B + 5 dB, for L_B greater than 38 dB(A)

10.57 Note that a higher noise level is permissible during the night than during the day as it is assumed that residents would be indoors. The night-time criterion is derived from sleep disturbance criterion referred to in ETSU-R-97, with an allowance of 10 dB for attenuation through an open window.

10.58 The wind speeds at which the acoustic impact is considered are less than or equal to 12 ms^{-1} at a height of 10 m and are likely to be the acoustically critical wind speeds. Above these wind speeds, as stated in ETSU-R-97, reliable measurements of background and turbine noise are difficult to make. However, if a wind farm meets the noise criteria at the wind speeds presented, it is most unlikely that it would cause any greater loss of amenity at higher wind speeds due to increasing background noise levels masking wind farm generated noise.

10.59 It is important to note that, since reactions to noise are subjective, it is not possible to guarantee that a given development would not result in any adverse comment with regard to noise as the response to any given noise will vary from person to person. Consequently, standards and guidance that relate to environmental noise

are typically presented in terms of criteria that would be expected to be considered acceptable by the majority of the population.

Construction Noise

10.60 To ensure adequate assessment of the potential impacts of the construction noise from the Proposed Development the following steps have been taken:

- Baseline noise criteria are established from the appropriate guidance BS 5228-1:2009;
- Noise levels due to on-site construction activities are predicted at the most sensitive residential properties in accordance with the BS 5228-1:2009 standard;
- Predicted noise levels due to construction traffic at the same residential properties are made using the BS 5228-1:2009 standard;
- The combined effect of on-site construction activities with construction traffic is compared with the target level specified by BS 5228-1:2009; and
- Predictions of the level of vibration due to blasting are made using BS 5228-2:2009 and the significance evaluated using BS 6472-2:2008.

Baseline Conditions

Operational Noise

10.61 The Proposed Development is located approximately 2 km north-west of Nant-y-moel. The surrounding area is predominantly rural in nature. The general noise character is typical of a rural environment with noise from farm machinery, sheep, cattle, and birds, with the occasional overhead aircraft. There is also a contribution from the forestry, rivers and A-roads located nearby.

10.62 Background noise measurements were undertaken by RES at three locations in accordance with ETSU-R-97 and in consultation with Bridgend County Borough Council as detailed in **Table 10.4**. In addition to the measurements made by RES, data from a background noise survey carried out at four locations (Abergwynfi, Blaen Cwmdu Farm, Blaengarw, Bryn Coed) in April/May 2013 to inform the acoustic assessment of Llnyfi Afan wind farm[17] has also been considered.

Table 10.4 - Background Noise Survey Details

[17] Llynfi Afan Renewable Energy Park, Environmental Noise Impact Assessment, Report HM: 2720/R1, 31 May 2013, Bridgend Council, Planning Reference Number: P/10/844/FUL

House Name	Measurement Period		
	Start	End	Duration (days)
Nantymoel Farm	15/02/18	22/03/18	36
Queen Street	15/02/18	06/04/18	51
Ty-Talgarth	22/03/18	06/04/18	16

10.63 The background noise monitoring equipment was housed in weather-proof enclosures and powered by lead-acid batteries. The microphones were placed at a height of approximately 1.2 m above ground and equipped with all-weather wind shields which also provide an element of water resistance.

10.64 The proprietary wind shields used are designed to reduce the effects of wind-generated noise at the microphone and accord with the recommendations of the IoA GPG in that they are the appropriate size and, in combination with the microphone, are certified by the manufacturer as meeting Type 1 / Class 1 precision standards.

10.65 Noise levels are monitored continuously, and summary statistics stored every 10 minutes in the internal memory of each meter. The relevant statistic measured is the $L_{A90,10min}$ (The A-weighted sound pressure level exceeded for 90 % of the 10 minute interval).

10.66 The sound level meters were placed away from reflecting walls and vegetation. Photos of the equipment, in situ, may be seen in **Technical Appendix 10.5**. The apparatus were calibrated before and after the survey period and the maximum drift detected was 0.1 dB, which is within the required range recommended in the IoA GPG. All instrumentation has been subject to laboratory calibration traceable to national standards within the last 24 months, as recommended in the IoA GPG. Details are provided in **Technical Appendix 10.6**.

10.67 **Charts 1-3** (see **Technical Appendix 10.7** for all charts) show the measured wind rose at the site over the background noise survey period at each survey position, as measured by the meteorological mast located on-site.

10.68 For illustrative purposes, **Chart 4** shows the measured wind rose over an extended period (21/12/05 – 13/10/11) as measured by a meteorological mast located 18 km from the proposed site. As previously discussed, the noise prediction model employed is likely to overestimate the real noise immission levels for locations not downwind of the turbines. **Chart 4** therefore may aid the reader as to the likelihood of over-estimation due to this factor.

10.69 The noise data has been cross-referenced with rainfall data measured at the on-site met mast using a rain gauge. Any noise data identified as having been affected by rainfall has been removed from the analysis as shown in **Charts 5 to 10**.

10.70 Short-term periods of increased noise levels considered to be atypical have been removed from the dataset. The excluded data is shown in **Charts 5 to 10.**

10.71 A directional analysis was completed in order to determine if any trends consistent with the influence of existing wind turbines on the noise levels recorded were present. No significant directional trends attributable to the existing wind farms were noted.

10.72 Given the lack of directional trends in the data, filtering by wind direction to remove any influence from the existing turbines was not deemed appropriate. Instead, the predicted noise levels due to the existing wind farms, weighted by the directional distribution experienced during the survey period, were subtracted from the ambient noise levels recorded. Both the measured ambient noise levels and resulting background noise levels are shown in **Charts 5 to 10**.

10.73 It was necessary to take directionality into account as in some instances the downwind predicted noise levels were greater than the ambient levels recorded, illustrating the conservatism of the propagation model.

10.74 The high noise levels recorded at Nantymoel Farm are due to the influence of river noise. The high noise levels recorded at Blaen Cwmdu Farm were due to construction noise and a stream.

10.75 **Charts 5-7** show $L_{A90,10min}$ correlated against wind speed for quiet daytime periods at each survey location. In each case, a 'best fit' line has been fitted to the data and the equation of the regression polynomial has been provided in the chart.

10.76 **Charts 8-10 s**how $L_{A90,10min}$ correlated against the wind speed for night-time periods at each survey location. In each case, a 'best fit' line has been fitted to the data and the equation of the regression polynomial has been provided in the chart.

10.77 **Table 10.5** and **Table 10.6** detail the $L_{A90,10min}$ background noise levels calculated from the ambient noise levels measured at the three RES survey locations along with the background noise levels measured at the four previous survey locations for the Llynfi Afan wind farm:

Table 10.5 - Quiet Daytime Noise Levels (dB(A) re 20 µPa)

House Name	Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Abergwynfi	23.1	23.1	23.6	24.4	25.6	27.1	28.8	30.7	32.7	34.8	36.8	38.9
Blaen Cwmdu Farm	41.9	41.4	41.2	41.2	41.3	41.5	41.6	41.6	41.5	41.0	40.3	39.1
Blaengarw	25.8	26.0	26.8	28.0	29.6	31.2	32.7	33.9	34.8	35.0	34.4	32.8
Bryn Coed	23.0	25.2	27.4	29.5	31.5	33.3	34.7	35.6	36.0	35.7	34.7	32.9
Nantymoel Farm	41.8	41.8	41.8	41.8	41.8	41.8	41.8	41.9	42.3	43.0	43.7	44.6

House Name	Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Queen Street	29.9	29.9	29.9	29.9	29.9	30.7	31.7	32.9	34.9	37.7	40.2	42.9
Ty-Talgarth	33.6	34.3	35.3	35.9	35.9	36.3	37.4	38.3	39.2	39.2	39.2	39.2

Table 10.6 - Night-time Noise Levels (dB(A) re 20 µPa)

House Name	Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Abergwynfi	22.2	21.6	21.4	21.7	22.3	23.2	24.4	25.7	27.2	28.8	30.5	32.1
Blaen Cwmdu Farm	41.7	41.4	41.4	41.4	41.5	41.5	41.5	41.4	41.2	40.7	39.9	38.9
Blaengarw	26.3	24.9	24.7	25.4	26.7	28.3	29.9	31.2	31.8	31.4	29.7	26.5
Bryn Coed	25.6	24.4	24.3	24.9	26.1	27.5	29.0	30.3	31.1	31.3	30.5	28.4
Nantymoel Farm	40.6	40.6	40.6	40.6	40.6	40.6	40.7	41.3	42.0	43.0	43.9	43.9
Queen Street	24.8	24.8	25.7	26.3	27.2	28.5	30.0	31.7	33.6	37.1	40.3	40.3
Ty-Talgarth	35.3	35.3	35.3	35.3	35.3	35.9	37.1	38.2	38.8	38.8	38.8	38.8

Construction Noise

10.78 For the on-site construction noise assessment, Annex E of BS 5228-1:2009 provides guidance on setting environmental noise targets. Several methods of assessing the significance of noise levels are presented in Annex E and the most applicable to the construction of the Proposed Development is the ABC method. The ABC method sets threshold noise levels for specific periods based on the ambient noise levels.

Potential Impacts

Potential Operational Impacts

Noise Propagation Modelling

10.79 The locations of the turbines which make up the Proposed Development are provided in **Table 10.7** and shown in **Figure 10.1**. A mix of hub heights is proposed within the overall tip height of 149.9 m.

Table 10.7: Location of Proposed Turbines

Turbine	Ordnance Survey of Great Britain (OSGB) Co-ordinates		Hub Height (m)
	X (m)	Y (m)	
T1	290447	194753	77.5
T2	290975	194891	77.5
T3	291597	194671	97.4
T4	292020	194782	97.4
T5	292241	194567	97.4
T6	292513	194333	77.5
T7	291182	194634	97.4

10.80 The locations of the nearest residential properties to the turbines have been determined by inspection of relevant maps and through site visits. More residential properties may have been identified but have not been considered critical to this acoustic assessment or may be adequately represented by another residential property. The locations considered are listed in **Table 10.8** and are also shown in **Figure 10.1**.

10.81 The distances from each residential property to the nearest turbine are given in **Table 10.8**. It can be seen that the minimum house-to-turbine separation is 1163m.

Table 10.8: Location of Residential Properties and Distances to Nearest Proposed Turbine

House Name	House ID	OSGB Co-ordinates		Distance (m)	Nearest Turbine
		X (m)	Y (m)		
Brynbedw House	H1	290444	193183	1570	T1
1 Greenfield Terrace	H2	294341	195716	2292	T6
Nantymoel Farm	H3	293130	193296	1207	T6
Bryn Eglur	H4	289909	193514	1351	T1
60 Vale View Terrace	H5	293425	193458	1264	T6
13 Scotch Street	H6	289339	196040	1698	T1

House Name	House ID	OSGB Co-ordinates		Distance (m)	Nearest Turbine
		X (m)	Y (m)		
14 Pwllgarn Terrace	H7	290069	193653	1163	T1
Residential Caravan	H8	290722	193207	1499	T7
Abergwynfi	H9	289368	196146	1762	T1
Blaen Cwmdu Farm	H10	287709	192104	3810	T1
Blaengarw	H11	290048	193644	1179	T1
Bryn Coed	H12	287062	195082	3401	T1
40 High Street	H13	289431	196124	1706	T1
30 Queen Street	H14	290404	193174	1580	T1
Ty-Talgarth	H15	293626	193025	1717	T6

10.82 Although not finalised, the candidate turbine type for the Proposed Development is the Vestas V105-3.6MW turbine which is representative of turbine models with similar dimensions and rated powers. Acoustic emission data from the manufacturer's general specification for this machine is used in the analysis[18]. The manufacturer has identified these values as warranted although no independent test reports are available to indicate whether any margin has been incorporated, therefore 2 dB has been added to the warranted levels as a conservative measure as recommended by the IoA GPG. Details used in this analysis are as follows:

- hub heights of 77.5 and 97.4 m;
- a rotor diameter of 105 m;
- sound power levels, L_{WA}, for standardised 10 m height wind speeds (v_{10}) as shown in **Table 10.9**;
- octave band sound power level data, at a standardised 10 m height wind speed of 8 ms^{-1}, as shown in **Table 10.10**;
- tonal emission characteristics such that no clearly audible tones are present at any wind speed.

[18] 'Performance Specification V105 – 3.6 MW 50/60 Hz', Vestas Document ID: 0056-4779 V01, 2016-10-21

Table 10.9 – A-Weighted Sound Power Levels (dB(A) re 1 pW) for the Vestas V105-3.6MW Wind Turbine

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	Warranted 77.5m Hub	77.5m Hub Plus Uncertainty	Warranted 97.4m Hub	97.4m Hub Plus Uncertainty
1	93.1	95.1	93.1	95.1
2	93.1	95.1	93.1	95.1
3	93.1	95.1	93.1	95.1
4	94.6	96.6	95.0	97.0
5	98.4	100.4	99.0	101.0
6	102.3	104.3	102.9	104.9
7	104.5	106.5	104.7	106.7
8	104.9	106.9	104.9	106.9
9	104.9	106.9	104.9	106.9
10	104.9	106.9	104.9	106.9
11	104.9	106.9	104.9	106.9
12	104.9	106.9	104.9	106.9

Table 10.10 - Octave Band A-Weighted Sound Power Levels (dB(A) re 1 pW) at a Standardised 10 m Height Wind Speed of 8 ms^{-1} for the Vestas V105-3.6MW Wind Turbine

Octave Band (Hz)	8 ms^{-1}
63	86.0
125	96.5
250	99.1
500	101.6
1000	100.6
2000	97.9
4000	92.6
8000	76.5
OVERALL	106.9

Predictions of Noise Levels at Residential Properties

10.83 **Table 10.11** shows the predicted noise immission levels at the nearest residential properties at each wind speed considered, calculated from the operation of the

Proposed Development. The property with the highest predicted noise immission level of 36.3 dB(A) is H7 (14 Pwllgarn Terrace).

10.84 **Figure 10.1** shows an isobel (i.e. noise contour) plot for the site at a 10 m height wind speed of 8 ms^{-1}. Such plots are useful for evaluating the noise 'footprint' of a given development.

Table 10.11: Predicted Noise Levels At Nearby Residential Properties, dB(A)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H1	21.1	21.1	21.1	23.0	27.0	30.9	32.7	32.9	32.9	32.9	32.9	32.9
H2	15.9	15.9	15.9	17.8	21.8	25.7	27.5	27.7	27.7	27.7	27.7	27.7
H3	21.4	21.4	21.4	23.3	27.3	31.2	33.0	33.2	33.2	33.2	33.2	33.2
H4	23.7	23.7	23.7	25.6	29.6	33.5	35.3	35.5	35.5	35.5	35.5	35.5
H5	21.4	21.4	21.4	23.3	27.3	31.2	33.0	33.2	33.2	33.2	33.2	33.2
H6	17.0	17.0	17.0	18.9	22.9	26.8	28.6	28.8	28.8	28.8	28.8	28.8
H7	24.5	24.5	24.5	26.4	30.4	34.3	36.1	36.3	36.3	36.3	36.3	36.3
H8	20.3	20.3	20.3	22.2	26.2	30.1	31.9	32.1	32.1	32.1	32.1	32.1
H9	18.2	18.2	18.2	20.1	24.1	28.0	29.8	30.0	30.0	30.0	30.0	30.0
H10	12.0	12.0	12.0	13.9	17.9	21.8	23.6	23.8	23.8	23.8	23.8	23.8
H11	24.4	24.4	24.4	26.3	30.3	34.2	36.0	36.2	36.2	36.2	36.2	36.2
H12	9.7	9.7	9.7	11.6	15.6	19.5	21.3	21.5	21.5	21.5	21.5	21.5
H13	18.6	18.6	18.6	20.5	24.5	28.4	30.2	30.4	30.4	30.4	30.4	30.4
H14	20.9	20.9	20.9	22.8	26.8	30.7	32.5	32.7	32.7	32.7	32.7	32.7
H15	21.4	21.4	21.4	23.3	27.3	31.2	33.0	33.2	33.2	33.2	33.2	33.2

10.85 Noise levels at 12 of the 15 nearest residential properties are below 35 dB(A) such that residential amenity would be sufficiently protected according to ETSU-R-97 without further assessment requiring to be undertaken. These residential properties are H1, H2, H3, H5, H6, H8, H9, H10, H12, H13, H14 and H15.

10.86 There are three properties that have predicted noise levels greater than this simplified noise criteria as indicated in **Table 10.11**. Therefore the 'full' acoustic assessment need only be considered at these locations: namely H4, H7 and H11. However, as background noise measurements were carried out at additional locations as agreed with the local authority, these properties (H3, H9, H10, H12, H14 and H15) have also been considered in the full acoustic assessment so as to provide

a more comprehensive description of the acoustic impact of the Proposed Development.

Acoustic Acceptance Criteria

10.87 As stated previously, during daytime periods and at low background noise levels, a lower fixed limit of 35-40 dB(A) is applicable with the exact value dependent upon a number of factors: the number of noise affected residential properties; the potential impact on the power output of the Proposed Development and the likely duration and level of exposure. These factors are considered in the following paragraph and the resulting criteria are shown in **Table 10.12**.

10.88 Justification for the daytime lower limit, considering each of the factors recommended by ETSU-R-97 and the guidance provided by the IoA GPG, is as follows:

- ***Number of noise affected residential properties:*** Three of the considered receptor locations (H4, H7 & H11), representing a row of houses to the north of Blaengarw, have predicted noise levels greater than 35 dB(A);
- ***Potential impact on the power output of the wind farm:*** The Proposed Development can be considered a medium scale development as it has a rated power output of 25.2 MW should the turbine type considered in the acoustic assessment be installed;
- ***The likely duration and level of exposure:*** The amount of time that noise levels of greater than 35 dB(A) are predicted is limited to periods of sufficiently high wind speed. Noise levels would also be reduced when properties are not located downwind of the wind turbines. None of the residential properties with predicted noise levels of greater than 35 dB(A) are downwind of the Proposed Development in the predominant wind direction.

10.89 Despite the explanations presented above indicating that a mid-range lower daytime noise limit would be justifiable, RES has adopted a daytime lower limit of 35 dB(A) for the assessment of the Proposed Development alone as a conservative measure.

Table 10.12: Permissible Noise Level Criteria

Time of Day	Permissible Noise Level
Daytime	• 35.0 dB(A) for L_B less than 30.0 dB(A) • L_B + 5 dB, for L_B greater than 30.0 dB(A)
Night-time	• 43.0 dB(A) for L_B less than 38.0 dB(A) • L_B + 5 dB, for L_B greater than 38.0 dB(A)

Calculation of Noise Limits from Baseline Conditions

10.90 The background noise levels from **Table 10.5** and **Table 10.6** have been used to calculate the noise limits at the background noise measurement locations. **Table 10.13** shows the daytime noise limits and **Table 10.14** the night time noise limits.

The noise limits at wind speeds of below 4 ms^{-1} at Blaen Cwmdu Farm have been set equal to the limit at 4 ms^{-1} despite the background noise best fit line suggesting that they increase as a conservative measure.

Table 10.13 - Recommended Daytime Noise Limits (dB(A) re 20 µPa)

House Name	Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Abergwynfi (H9)	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.7	37.7	39.8	39.8	39.8
Blaen Cwmdu Farm (H10)	46.2	46.2	46.2	46.2	46.3	46.5	46.6	46.6	46.5	46.0	46.0	46.0
Blaengarw (H11)	35.0	35.0	35.0	35.0	35.0	36.2	37.7	38.9	39.8	40.0	40.0	40.0
Bryn Coed (H12)	35.0	35.0	35.0	35.0	36.5	38.3	39.7	40.6	41.0	40.7	40.7	40.7
Nantymoel Farm (H3)	46.8	46.8	46.8	46.8	46.8	46.8	46.8	46.9	47.3	48.0	48.7	49.6
Queen Street (H14)	35.0	35.0	35.0	35.0	35.0	35.7	36.7	37.9	39.9	42.7	45.2	47.9
Ty-Talgarth (H15)	38.6	39.3	40.3	40.9	40.9	41.3	42.4	43.3	44.2	44.2	44.2	44.2

Table 10.14 - Recommended Night-time Noise Limits (dB(A) re 20 µPa)

House Name	Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Abergwynfi (H9)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Blaen Cwmdu Farm (H10)	46.4	46.4	46.4	46.4	46.5	46.5	46.5	46.4	46.2	45.7	45.7	45.7
Blaengarw (H11)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Bryn Coed (H12)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Nantymoel Farm (H3)	45.6	45.6	45.6	45.6	45.6	45.6	45.7	46.3	47.0	48.0	48.9	48.9

House Name	Standardised 10 m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
Queen Street (H14)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.3	45.3
Ty-Talgarth (H15)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.2	43.8	43.8	43.8	43.8

10.91 The recommendations of ETSU-R-97 state that where there are groups of properties that are likely to have a similar background noise environment, it is appropriate to use data from one representative location as the basis for assessment at the other properties. The survey results inferred to be representative for each property is shown in **Table 10.15**. The choice has been made considering the distance from each survey location and the likelihood of experiencing a broadly similar exposure.

Table 10.15 - Assumed Representative Background Noise Survey Locations

House Name	House ID	Assumed Representative Background Noise Survey
Brynbedw House	H1	Queen Street
1 Greenfield Terrace	H2	Ty-Talgarth
Nantymoel Farm	H3	Nantymoel Farm
Bryn Eglur	H4	Blaengarw
60 Vale View Terrace	H5	Ty-Talgarth
13 Scotch Street	H6	Abergwynfi
14 Pwllgarn Terrace	H7	Blaengarw
Residential Caravan	H8	Queen Street
Abergwynfi	H9	Abergwynfi
Blaen Cwmdu Farm	H10	Blaen Cwmdu Farm
Blaengarw	H11	Blaengarw
Bryn Coed	H12	Bryn Coed
40 High Street	H13	Abergwynfi
30 Queen Street	H14	Queen Street
Ty-Talgarth	H15	Ty-Talgarth

10.92 The results from the surveys made at Nantymoel Farm and Blaen Cwmdu Farm are not inferred to other locations as a conservative measure as they are impacted by noise sources specific to that locality. A check on whether the conclusions of the assessment would differ should data from these locations be discarded completely and background noise levels measured elsewhere used in their place has been made and no change was found.

10.93 As recommended in ETSU-R-97, the absolute lower noise limits may be increased up to 45 dB(A) if the occupant of a property has a financial involvement in the Proposed Development. However, whilst some of the nearby properties may qualify for such an increase, these limits have not been adopted in the assessment as a conservative measure.

Acoustic Assessment

10.94 **Table 10.16** shows a comparison of the predicted noise levels with the recommended daytime noise limits for each residential property where the full assessment procedure is being applied. The predicted noise levels at 1 ms^{-1} and 2 ms^{-1} have been assumed as equal to 3 ms^{-1} as a conservative measure as noise levels at these wind speeds would typically be less. The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit. A negative value indicates that the predicted noise level is within the limit. **Table 10.17** shows a comparison with the recommended night-time noise limits.

10.95 Noise levels at all locations are within both the daytime and night-time noise limits at all wind speeds considered. The minimum margin of predicted noise levels below the daytime noise limits is -1.7 dB(A). The minimum margin during night-time periods is -6.7 dB(A).

Table 10.16 - Comparison of Predicted Noise Levels and Daytime Noise Limits - (dB(A) re 20 µPa)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1			2			3			4		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H3	21.4	46.8	-25.4	21.4	46.8	-25.4	21.4	46.8	-25.4	23.1	46.8	-23.7
H4	23.7	35.0	-11.3	23.7	35.0	-11.3	23.7	35.0	-11.3	25.3	35.0	-9.7
H7	24.5	35.0	-10.5	24.5	35.0	-10.5	24.5	35.0	-10.5	26.2	35.0	-8.8
H9	18.2	35.0	-16.8	18.2	35.0	-16.8	18.2	35.0	-16.8	19.9	35.0	-15.1
H10	12.0	46.2	-34.2	12.0	46.2	-34.2	12.0	46.2	-34.2	13.7	46.2	-32.5
H11	24.4	35.0	-10.6	24.4	35.0	-10.6	24.4	35.0	-10.6	26.0	35.0	-9.0
H12	9.7	35.0	-25.3	9.7	35.0	-25.3	9.7	35.0	-25.3	11.4	35.0	-23.6
H14	20.9	35.0	-14.1	20.9	35.0	-14.1	20.9	35.0	-14.1	22.6	35.0	-12.4

H15	21.4	38.6	-17.2	21.4	39.3	-18.0	21.4	40.3	-18.9	23.1	40.9	-17.8

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	5			6			7			8		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H3	27.0	46.8	-19.8	30.9	46.8	-15.9	32.9	46.8	-13.9	33.2	46.9	-13.7
H4	29.2	35.0	-5.8	33.1	36.2	-3.1	35.1	37.7	-2.6	35.5	38.9	-3.4
H7	30.0	35.0	-5.0	33.9	36.2	-2.3	36.0	37.7	-1.7	36.3	38.9	-2.6
H9	23.7	35.0	-11.3	27.6	35.0	-7.4	29.7	35.0	-5.3	30.0	35.7	-5.7
H10	17.6	46.3	-28.7	21.5	46.5	-25.0	23.5	46.6	-23.1	23.8	46.6	-22.8
H11	29.9	35.0	-5.1	33.8	36.2	-2.4	35.9	37.7	-1.8	36.2	38.9	-2.7
H12	15.3	36.5	-21.2	19.2	38.3	-19.1	21.2	39.7	-18.5	21.5	40.6	-19.1
H14	26.5	35.0	-8.5	30.4	35.7	-5.3	32.4	36.7	-4.3	32.7	37.9	-5.2
H15	27.0	40.9	-14.0	30.9	41.3	-10.4	32.9	42.4	-9.5	33.2	43.3	-10.1

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H3	33.2	47.3	-14.1	33.2	48.0	-14.8	33.2	48.7	-15.5	33.2	49.6	-16.4
H4	35.5	39.8	-4.3	35.5	40.0	-4.5	35.5	40.0	-4.5	35.5	40.0	-4.5
H7	36.3	39.8	-3.5	36.3	40.0	-3.7	36.3	40.0	-3.7	36.3	40.0	-3.7
H9	30.0	37.7	-7.7	30.0	39.8	-9.8	30.0	39.8	-9.8	30.0	39.8	-9.8
H10	23.8	46.5	-22.7	23.8	46.0	-22.2	23.8	46.0	-22.2	23.8	46.0	-22.2
H11	36.2	39.8	-3.6	36.2	40.0	-3.8	36.2	40.0	-3.8	36.2	40.0	-3.8
H12	21.5	41.0	-19.5	21.5	40.7	-19.2	21.5	40.7	-19.2	21.5	40.7	-19.2
H14	32.7	39.9	-7.2	32.7	42.7	-10.0	32.7	45.2	-12.5	32.7	47.9	-15.2
H15	33.2	44.2	-11.0	33.2	44.2	-11.0	33.2	44.2	-11.0	33.2	44.2	-11.0

The term L_p is used to denote the predicted noise level due to the operation of the Proposed Development
The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit

Table 10.17 - Comparison of Predicted Noise Levels and Night Time Limits - (dB(A) re 20 µPa)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1			2			3			4		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H3	21.4	45.6	-24.3	21.4	45.6	-24.3	21.4	45.6	-24.3	23.1	45.6	-22.6
H4	23.7	43.0	-19.3	23.7	43.0	-19.3	23.7	43.0	-19.3	25.3	43.0	-17.7
H7	24.5	43.0	-18.5	24.5	43.0	-18.5	24.5	43.0	-18.5	26.2	43.0	-16.8
H9	18.2	43.0	-24.8	18.2	43.0	-24.8	18.2	43.0	-24.8	19.9	43.0	-23.1
H10	12.0	46.4	-34.4	12.0	46.4	-34.4	12.0	46.4	-34.4	13.7	46.4	-32.7
H11	24.4	43.0	-18.6	24.4	43.0	-18.6	24.4	43.0	-18.6	26.0	43.0	-17.0
H12	9.7	43.0	-33.3	9.7	43.0	-33.3	9.7	43.0	-33.3	11.4	43.0	-31.6
H14	20.9	43.0	-22.1	20.9	43.0	-22.1	20.9	43.0	-22.1	22.6	43.0	-20.4
H15	21.4	43.0	-21.6	21.4	43.0	-21.6	21.4	43.0	-21.6	23.1	43.0	-19.9

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	5			6			7			8		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H3	27.0	45.6	-18.7	30.9	45.6	-14.8	32.9	45.7	-12.8	33.2	46.3	-13.1
H4	29.2	43.0	-13.8	33.1	43.0	-9.9	35.1	43.0	-7.9	35.5	43.0	-7.5
H7	30.0	43.0	-13.0	33.9	43.0	-9.1	36.0	43.0	-7.0	36.3	43.0	-6.7
H9	23.7	43.0	-19.3	27.6	43.0	-15.4	29.7	43.0	-13.3	30.0	43.0	-13.0
H10	17.6	46.5	-28.9	21.5	46.5	-25.0	23.5	46.5	-23.0	23.8	46.4	-22.6
H11	29.9	43.0	-13.1	33.8	43.0	-9.2	35.9	43.0	-7.1	36.2	43.0	-6.8
H12	15.3	43.0	-27.7	19.2	43.0	-23.8	21.2	43.0	-21.8	21.5	43.0	-21.5
H14	26.5	43.0	-16.5	30.4	43.0	-12.6	32.4	43.0	-10.6	32.7	43.0	-10.3
H15	27.0	43.0	-16.0	30.9	43.0	-12.1	32.9	43.0	-10.1	33.2	43.2	-10.0

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H3	33.2	47.0	-13.9	33.2	48.0	-14.8	33.2	48.9	-15.8	33.2	48.9	-15.8
H4	35.5	43.0	-7.5	35.5	43.0	-7.5	35.5	43.0	-7.5	35.5	43.0	-7.5
H7	36.3	43.0	-6.7	36.3	43.0	-6.7	36.3	43.0	-6.7	36.3	43.0	-6.7
H9	30.0	43.0	-13.0	30.0	43.0	-13.0	30.0	43.0	-13.0	30.0	43.0	-13.0
H10	23.8	46.2	-22.4	23.8	45.7	-21.9	23.8	45.7	-21.9	23.8	45.7	-21.9
H11	36.2	43.0	-6.8	36.2	43.0	-6.8	36.2	43.0	-6.8	36.2	43.0	-6.8
H12	21.5	43.0	-21.5	21.5	43.0	-21.5	21.5	43.0	-21.5	21.5	43.0	-21.5
H14	32.7	43.0	-10.3	32.7	43.0	-10.3	32.7	45.3	-12.6	32.7	45.3	-12.6
H15	33.2	43.8	-10.6	33.2	43.8	-10.6	33.2	43.8	-10.6	33.2	43.8	-10.6

The term L_p is used to denote the predicted noise level due to the operation of the Proposed Development
The term ΔL is used to denote the difference between the predicted wind farm noise level and the recommended limit

Potential Construction Impacts

Construction Noise Assessment

10.96 Primary activities creating noise during the construction period include the construction of the turbine bases; the erection of the turbines; the excavation of trenches for cables; and the construction of associated hard standings, access tracks and construction compound. Noise from vehicles on local roads and access tracks would also arise due to the delivery of turbine components and construction materials, notably aggregates, concrete and steel reinforcement.

10.97 It should be noted that the exact methodology and timing of construction activities cannot be predicted at this time, this assessment is therefore based on assumptions representing a worst-case approach.

Construction Noise Predictions

10.98 The plant assumed for each construction activity is shown in **Table 10.18**. The number of items indicates how many of each plant are required for the specified activity, and the duration of activity is a percentage of a given 12 hour day period needed for that plant to operate. Overall sound power levels are based upon the data in Annex C of BS 5228-1:2009.

Table 10.18: Construction Phases and Sound Power Levels

Activities	Plant	Sound Power (L_{WA})	No. Items	Activity Duration (%)	Effective Sound Power (L_{WA})
Construct Temporary site compounds	Tracked excavator	113	2	100	119
	Dump truck	113	2	100	
	Tipper lorry	107	2	50	
	Vibratory roller	102	1	75	
	Lorry	108	1	75	
Construct site tracks	Tracked excavator	113	3	100	122
	Dump truck	113	2	75	
	Tipper lorry	107	4	50	
	Dozer	109	1	100	
	Vibratory roller	102	1	75	
	Excavator mounted rock breaker	121	1	50	
Construct Substations	Tracked excavator	113	1	100	117
	Concrete mixer truck	108	2	50	

Activities	Plant	Sound Power (L_{WA})	No. Items	Activity Duration (%)	Effective Sound Power (L_{WA})
	Lorry	108	1	50	
	Telescopic Handler	99	1	100	
	Piling rig	117	1	50	
Construct crane hardstandings	Tracked excavator	113	3	100	120
	Dump truck	113	2	100	
	Tipper lorry	107	4	50	
	Vibratory roller	102	1	50	
Construct Turbine Foundations	Tracked excavator	113	2	75	122
	Dump truck	113	2	75	
	Concrete mixer truck	108	4	100	
	Mobile telescopic crane	110	1	50	
	Concrete pump	106	2	100	
	Water pump	93	1	100	
	Hand-held pneumatic breaker	111	1	50	
	Compressor	103	3	50	
	Poker vibrator	106	3	50	
	Excavator mounted rock breaker	121	1	50	
Excavate and Lay Site Cables	Tracked excavator	113	2	100	122
	Dump truck	113	2	75	
	Tractor (Towing Equipment)	108	1	75	
	Tractor (Towing Trailer)	107	1	75	
	Vibratory plate	108	1	50	
	Excavator mounted rock breaker	121	1	50	
Erect Turbine	Mobile telescopic crane	110	2	75	119
	Lorry	108	1	75	
	Diesel generator	102	1	100	

Activities	Plant	Sound Power (L_{WA})	No. Items	Activity Duration (%)	Effective Sound Power (L_{WA})
	Torque guns	111	4	100	
Reinstate Crane Bases	Tracked excavator	113	1	75	115
	Dump truck	113	1	75	
Lay Cable to Substations	Wheeled loader	108	1	100	117
	Saw	114	1	50	
	Hand-held pneumatic breaker	111	1	50	
	Dump truck	113	1	75	
	Tipper lorry	107	1	50	
	Vibratory plate	108	1	75	
	Tandem roller	102	1	75	
	Tractor (Towing Trailer)	107	1	50	
	Lorry	108	1	75	
Forestry Felling	Saw	114	1	100	116
	Harvester	108	2	100	
Borrow Pits	Excavator mounted rock breaker	121	1	100	126
	Dump truck	113	2	75	
	Dozer	109	1	100	
	Tracked semi-mobile crusher	124	1	100	
	Tracked excavator	113	1	100	

10.99 Predictions of construction noise levels have been carried out using the methods prescribed in Annex F of BS 5228-1:2009[19]. The worst case scenario, where each construction activity takes place at the nearest proposed location to the residential property being assessed, is considered. The locations of the construction activities are taken from **Figure 3.1 - Infrastructure Layout**. The results of these predictions, made at six of the nearest residential properties to the Proposed Development, are shown in **Table 10.19**.

[19] A 50% mixed ground attenuation has been used throughout to conservatively account for the arable nature of ground conditions at the site

10.100 In all cases average noise levels over the construction period would be lower as the worst case is presented for when the activities are closest to the residential property.

Table 10.19: Predicted Sound Pressure Level due to Construction Noise (dB L_{Aeq})

Activity	H3	H5	H6	H7	H8	H13
Construct Temporary Site Compounds	40.3	40.0	37.4	39.3	39.9	37.6
Construct Site Tracks	48.5	48.0	46.3	48.8	46.3	46.3
Construct Substations	38.3	37.9	35.5	37.7	38.3	35.7
Construct Crane Hard-standings	46.5	46.0	43.1	46.8	44.3	43.1
Construct Turbine Foundations	48.3	47.8	44.9	48.6	46.1	44.9
Excavate and Lay Site Cables	47.7	47.2	44.3	48.0	45.5	44.3
Erect Turbine	44.8	44.3	41.4	45.1	42.6	41.4
Reinstate Crane Bases	40.8	40.3	37.4	41.1	38.6	37.4
Lay Cable to Substations	38.3	37.9	35.5	37.7	38.3	35.7
Forestry Felling	34.0	34.0	37.2	33.9	33.8	37.9
Borrow Pits	47.8	47.8	43.9	45.7	46.4	44.1

Construction Traffic

10.101 Due to the delivery of construction material and wind farm components, vehicle movements either into or away from the site shall increase levels of traffic flow on public roads in the area. Traffic regularly accessing the site is assumed to be characterised by the sound power levels of Dump Trucks, Lorries and Concrete Mixers as a worst case. It is assumed that a total of 256 vehicle movements per day would be required during the most intense period of construction activity although this would only be the case for a maximum of seven days during foundation pouring. This is conservative compared to that identified in **Chapter 9 – Traffic, Transportation & Access** which anticipates a maximum of 90 journeys (180 movements) consisting of 60 mixer trucks, 5 HGVs and 25 site staff. The conservatism allows for on-site dump truck movements and some aggregate deliveries taking place.

10.102 Construction traffic noise has been quantified using the method described in BS 5228: 2009 Part 1. Using the distances from residential properties to the centre of the relevant carriageway where site traffic would be, the noise levels predicted are presented in **Table 10.20**. The maximum sound pressure level due to traffic flows during the most intensive period of activity is predicted to be 63.1 dB L_{Aeq}. The

properties where this could occur are adjacent to the proposed delivery route and, as such, correspond to the worst case.

10.103 As the route has yet to be finalised, for the purposes of this assessment it is assumed that the vehicles associated with foundation pouring would pass through Abergwynfi such that the worst-case traffic noise levels occur at properties adjacent to the A4107 as it passes through this location. Should an alternative access route be chosen this figure would remain the worst-case as the properties in Abergwynfi are located next to the road.

Table 10.20: Traffic Noise Predictions by Activity (dB L_{Aeq})

House ID	Dump Truck	Lorries	Concrete Mixer
H3	39.0	32.1	36.4
H5	40.0	33.1	37.4
H6	51.6	44.7	49.0
H7	37.6	30.7	35.0
H8	37.4	30.5	34.8
H13	60.6	53.8	58.0

10.104 The increase in noise level due to the presence of construction traffic on nearby roads has been quantified using the methodology set out in CRTN[20] based on the Annual Average Daily Flow data shown in **Table 9.3** of **Chapter 9 - Traffic, Transportation and Access**. The maximum predicted increase in daytime average traffic noise level is 0.5 dB(A). Given that a 3 dB(A) change is commonly regarded as the smallest subjectively perceptible difference in noise level, the predicted short-term change in traffic noise levels are considered negligible and not significant.

General Construction Noise in Conjunction with Traffic Noise

10.105 Worst case construction noise levels may arise when the following simultaneous activities occur: construction of temporary site compounds; construction of nearest access tracks; construction of substation; excavation and laying of site cables; construction of nearest crane hard-standings; and construction of nearest turbine foundations. Therefore cumulative predictions of these construction activities and the additional noise contribution from construction traffic have been calculated and are shown in **Table 10.21**.

10.106 It should be noted that the predictions exclude the screening effects of local topography therefore actual levels of noise experienced at nearby residential properties could be lower.

[20] Calculation of Road Traffic Noise (CRTN), HMSO Department of Transport, 1988.

Table 10.21: Predicted Noise Due to Combined Traffic Noise and Turbine Construction (dB L_{Aeq})

House ID	Construction Plant Noise	Traffic Noise	Combined Noise
H3	54.1	41.4	54.1
H5	53.7	42.4	53.7
H6	51.1	54.0	55.8
H7	54.4	40.0	54.4
H8	52.1	39.8	52.1
H13	51.2	63.1	63.1

Assessment of Construction Noise

10.107 In accordance with the ABC method of Annex E of BS 5228-1:2009, due to the relatively low levels of ambient noise in the vicinity of the Proposed Development, a Category A assessment is appropriate. This category sets threshold L_{Aeq} criteria of: 65 dB(A) during weekdays (0700-1900) and Saturdays (0700-1300); below 55 dB(A) at evenings and weekends; and below 45 dB(A) for night-time (2300-0700) periods.

10.108 **Table 10.21** shows that predicted noise levels from the combined effect of increased traffic flows and activities associated with the peak of construction activities are below the 65 dB(A) target level specified by BS 5228-1:2009 at all of the assessed residential properties such that significant effects would not be anticipated on weekdays (0700-1900) or Saturdays (0700-1300).

10.109 Construction noise levels at the peak of activity are predicted to exceed the 55 dB(A) target level on Saturdays between 1300-1900 at two locations: H6 and H13. Evenings, Sundays and night time periods are not included in the assessment as construction work is not scheduled to take place during these times with the exception of turbine erection and commissioning or periods of emergency work. The predictions made represent the worst-case combination of most intensive traffic activity with simultaneous construction activity at the nearest possible location to each residential property.

Assessment of Vibration due to Blasting

10.110 BS 5228-2:2009 provides guidance on the assessment of vibration due to blasting. A scaled distance graph is shown in Figure E.1 in Annex E of BS 5228.2:2009 which provides an indication of likely vibration magnitudes at various distances. This figure can be used to determine the level of vibration which would not be expected to be exceeded in 95 % of blasts for a given distance and charge size.

10.111 BS 6472-2:2008 details the maximum satisfactory magnitudes for vibration measured on a firm surface outside buildings with respect to human response. For up to three blast vibration events per day the generally accepted maximum satisfactory

magnitude at residential premises during daytime periods (0800-1800 Monday to Friday and 0800-1300 on Saturdays) is a peak particle velocity (ppv) of 6.0 to 10.0 mms^{-1}. In practice, the lower satisfactory magnitude should be used with the higher magnitude being justified on a case-by-case basis.

10.112 For a charge size of 900 kg the estimated vibration magnitude is 3.4 mms^{-1} at the nearest residential property to a proposed borrow pit which is approximately 1957 m away. This suggests that the probability of adverse comment is low.

Mitigation

Operational Noise

10.113 One of the key constraints and considerations in designing the layout of the turbines was the minimisation of potential noise impacts at the nearest residential receptors. As such the turbine layout was designed to ensure that there is an adequate separation distance between any of the proposed turbines and the nearest residential property.

10.114 Due to this consideration of noise impacts in the design of the Proposed Development, embedding mitigation measures in the turbine layout, no applied mitigation measures are required for the operation of the proposed turbines as noise levels due to the Proposed Development are below noise limits derived in accordance with ETSU-R-97 when considered on its own.

10.115 It is worth noting that the operation of many modern turbines may be altered by changing the pitch of the wind turbine blades resulting in a trade-off between power production and noise reduction. Operating turbines in such a noise-reduced mode would provide a potential mechanism for reducing the level of noise experienced at nearby residential properties but the acoustic assessment of the Proposed Development on its own, undertaken in accordance with best practice guidance that is considered robust, demonstrates that this is not required.

10.116 If planning permission is granted for the Proposed Development, planning conditions can be proposed to provide protection to nearby residents in the form of limits relating to noise level and tonality.

10.117 **Technical Appendix 10.8** contains a set of conditions that RES considers appropriate.

Construction Noise

10.118 For all activities, measures would be taken to reduce noise levels with due regard to practicality and cost as per the concept of ‘best practicable means’ as defined in Section 72 of the Control of Pollution Act 1974.

10.119 BS 5228-1:2009 states that the ‘attitude of the contractor’ is important in minimising the likelihood of complaints and therefore consultation with the local authority along with letter drops are advised to inform residents of intended activity. Non-acoustic factors, which influence the overall level of complaints such as mud on roads and

dust generation, would also be controlled through construction practices adopted on the site.

10.120 Furthermore, the following noise mitigation options could be implemented where appropriate:

- Consideration would be given to noise emissions when selecting plant and equipment to be used on site;
- All equipment should be maintained in good working order and fitted with the appropriate silencers, mufflers or acoustic covers where applicable;
- Stationary noise sources would be sited as far away as reasonably possible from residential properties; and
- The movement of vehicles to and from the site would be controlled and employees instructed to ensure compliance with the noise control measures adopted.

10.121 Site operations would be limited to 0700-1900 Monday to Saturday except during turbine erection and commissioning or during periods of emergency work. The following mitigation measures would be considered to adhere to the 55 dB(A) target level for Saturdays 1300-1900:

- Reduce the number of construction activities occurring simultaneously;
- Restrict the distance of construction activity from nearby properties during these times; &
- Reduce construction traffic as appropriate.

10.122 There are many strategies to reduce construction noise by the limitation of activities that would result in predicted noise levels being lower than the specified target. Any such measures should be considered adequate and the mitigation adopted should not be limited to the measures proposed.

10.123 With specific regard to blasting, it is proposed that the following mitigation measures are implemented:

- Good practice on blasting shall be followed;
- The vibration and air overpressure reduction methods outlined in Section 8.6.9.2 of BS 5228-2:2009 shall be adhered to where appropriate;
- Advance warning shall be given to nearby residents;
- Blasting should only occur between the hours of 0800-1800 on Mondays-Fridays or between the hours of 0800-1300 on Saturdays; and
- No more than three blasts per day should occur.

10.124 Depending upon the charge sizes required it may be prudent to perform trial blasts with smaller amounts of explosive and measure vibration magnitudes at various distances to more accurately determine how vibration propagates at the site.

10.125 As with operational noise, if planning permission is granted for the Proposed Development, planning conditions can be proposed so that appropriate noise mitigation measures and construction practices are included within the construction management plan.

Residual Effects

Operational

10.126 The acoustic assessment demonstrates that predicted noise levels at residential properties do not exceed the derived noise limits across all wind speeds. This should not be interpreted to mean that operational noise would be inaudible (or masked by background noise) under all conditions, but that the levels of noise are acceptable under ETSU-R-97 and associated guidance.

Construction

10.127 There may be an increase above the 55 dB(A) criteria level for Saturdays 1300-1900 at two locations although this can be mitigated by restricting the activities that are allowed to take place as necessary. At all other times predicted noise from worst case combination of increased traffic and site construction noise would not exceed relevant criteria and therefore no significant impacts are expected.

Cumulative Effects

Cumulative Operational Noise Assessment

10.128 An assessment of the cumulative acoustic impact of the Proposed Development in conjunction with the existing Llynfi Afan, Pant-y-Wal, Fforch Nest, Pant-y-Wal Extension, Pen y Cymoedd, Mynydd Bwllfa, Ferndale, Ffynnon Oer and Maerdy wind farms, along with the consented Foel Trawsnant scheme has been undertaken in accordance with the guidance on wind farm noise assessment; ETSU-R-97 and the IoA GPG. Consultation with Bridgend County Borough Council has been undertaken regarding the sites considered in the cumulative assessment along with the methodology adopted.

10.129 ETSU-R-97 states:

"It is clearly unreasonable to suggest that, because a wind farm has been constructed in the vicinity in the past which resulted in increased noise levels at some properties, the residents of those properties are now able to tolerate higher noise levels still. The existing wind farm should not be considered as part of the prevailing background noise."

10.130 The locations of the seven turbines that make up the Proposed Development, along with the other turbines considered in the cumulative assessment, are shown in **Figure 10.2**.

10.131 The residential properties considered in the cumulative assessment are those detailed in **Table 10.8.** The distances to the nearest turbine included in the cumulative assessment are given in **Table 10.22**.

Table 10.22: Distances from Residential Properties to Nearest Cumulative Turbine

House Name	House ID	Distance (m)	Nearest Turbine
Brynbedw House	H1	1570	T1
1 Greenfield Terrace	H2	2292	T6
Nantymoel Farm	H3	1207	T6
Bryn Eglur	H4	1131	L15
60 Vale View Terrace	H5	1264	T6
13 Scotch Street	H6	963	L2
14 Pwllgarn Terrace	H7	1163	T1
Residential Caravan	H8	1499	T7
Abergwynfi	H9	1033	L2
Blaen Cwmdu Farm	H10	1260	L13
Blaengarw	H11	1179	T1
Bryn Coed	H12	1332	L10
40 High Street	H13	982	L2
30 Queen Street	H14	1580	T1
Ty-Talgarth	H15	1572	X2

Turbines prefixed "T" are the proposed Upper Ogmore turbines, those prefixed "L" are the existing Llynfi Afan turbines and those prefixed "X" belong to the existing Pant-y-Wal Extension

Cumulative Assessment Methodology

10.132 ETSU-R-97 recommends that the derived noise limits applicable at nearby residential properties shall relate to the cumulative effects of noise from all wind turbines that may affect a particular location.

10.133 The methodology is therefore to:

- Predict noise immission levels at the nearest residential properties due to the Proposed Development, along with the other turbines to be considered in the cumulative assessment;
- Calculate the predicted cumulative noise levels by combining the predicted noise levels from all of the projects that are being considered; and
- Compare the cumulative predicted noise levels to criteria specified by relevant guidance, ETSU-R-97, to determine whether the cumulative predicted noise levels comply with ETSU-R-97 criteria.

10.134 The methodology outlined above is in accordance with the appropriate guidance on cumulative wind farm noise assessment as described in ETSU-R-97 and the IoA GPG.

Predictions of Noise Levels at Residential Properties

Llynfi Afan Wind Farm

10.135 The noise limits contained in the Decision Notice[21] are used to calculate the worst case predicted noise levels from the existing Llynfi Afan wind farm using the 'Controlling Property' method described in the IoA GPG as follows:

- Predictions are made using appropriate turbine noise data;
- Comparison is made between the predictions and the limits from the planning conditions in order to identify the controlling property; and
- If appropriate, the predictions are scaled by the minimum margin between the predictions and the conditioned noise limits at the controlling property. This yields predicted noise levels which do not exceed the conditioned noise limits at any property and are equal to the conditioned noise limit at the controlling property and wind speed(s).

10.136 The turbine installed at Llynfi Afan Wind Farm is the Gamesa G80 2MW turbine. Warranted acoustic data for this turbine is taken from the Llynfi Afan Environmental Statement[22] and an uncertainty of 2 dB has been included as recommended by the turbine manufacturer. Details used in this analysis are as follows:

- a hub height of 78 m;
- a rotor diameter of 80 m;
- sound power levels, L_{WA}, for standardised 10 m height wind speeds (v_{10}) as shown in **Table 10.23**; and
- octave band sound power level data, at a standardised 10 m height wind speed of 8 ms^{-1}, as shown in **Table 10.24**.

[21] Bridgend County Borough Council, Permission for Development, Planning Reference P/10/844/FUL, 18 July 2013

[22] Llynfi Afan Renewable Energy Park Environmental Noise Impact Statement, Report HM: 2720/R1, May 2013

Table 10.23: A-Weighted Sound Power Levels (dB(A) re 1 pW) for the Gamesa G80 2MW Wind Turbine

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	Warranted Plus Uncertainty
1	97.9
2	97.9
3	97.9
4	97.9
5	102.7
6	105.0
7	105.1
8	105.1
9	105.1
10	105.1
11	105.1
12	105.1

Table 10.24: Octave Band A-Weighted Sound Power Levels (dB(A) re 1 pW) at a Standardised 10 m Wind Speed of 8 ms^{-1} for the Gamesa G80 2MW Wind Turbine

Octave Band (Hz)	8 ms^{-1}
63	87.7
125	94.4
250	98.5
500	100.3
1000	98.9
2000	94.4
4000	87.7
8000	77.4
OVERALL	105.1

10.137 Predicted noise levels based on the installed turbine type demonstrate that the scheme could be operating right up to its conditioned daytime limit at Abergwynfi at standardised 10 m wind speeds of 6 – 8 ms^{-1}. This is consistent with the Supplementary Noise Information submitted for Llynfi Afan[23]. Scaling the predicted noise levels to the conditioned limits above these wind speeds would be increasingly unrealistic as the acoustic emission reaches its maximum at 7 ms^{-1}. Scaling the predicted noise levels to the conditioned limits below these wind speeds would make no difference to the results of the assessment.

[23] Llynfi Afan Renewable Energy Park Supplementary Noise Information, Report HM: 2720/R2, March 2014

10.138 No scaling is applied during night time periods as significant headroom (between 5 – 10 dB according to the IoA GPG) exists, implying that scaling to the limit would be unrealistic. Even if the predicted noise levels were scaled by 6 dB there would be no change to the results of the night time assessment.

10.139 The conservatism of the predicted noise levels attributable to Llynfi Afan is supported by the results of compliance testing[24] which show that the measured ambient noise levels, inclusive of background noise, are below that which would be predicted (using the propagation model and acoustic emission data adopted in this assessment) due to wind farm noise alone at 6 and 7 ms^{-1}. These are typically the wind speeds where wind farm noise levels are most prominent relative to background noise (see **Charts 5-10** for reference). As such, in the absence of corrections for background noise, these wind speeds represent those which enable the conservatism or otherwise of the modelling to be most accurately gauged. At lower wind speeds the wind farm noise decreases more rapidly than background noise whilst at higher wind speeds wind farm noise levels off and background noise continues to increase.

Pant-y-Wal, Fforch Nest & Pant-y-Wal Extension

10.140 The existing Pant-y-Wal, Fforch Nest & Pant-y-Wal Extension schemes were consented separately but have subsequently come under the same ownership and had their consented noise limits revised such that they are applicable to the entire scheme. These revised conditioned limits are used to determine the worst case predicted noise levels due to this scheme using the controlling property method as described in paragraph 10.135.

10.141 The turbine installed at these sites is the Nordex N90/2500 machine. Warranted acoustic data for this turbine with an allowance for uncertainty of 2 dB included, consistent with guidance provided by the manufacturer, has been used in this analysis. Details are as follows:

- a hub height of 70 m;
- a rotor diameter of 90 m;
- sound power levels, L_{WA}, for standardised 10 m height wind speeds (v_{10}) as shown in **Table 10.25**; and
- octave band sound power level data, at a standardised 10 m height wind speed of 8 ms^{-1}, as shown in **Table 10.26**.

[24] Hayes McKenzie, Llynfi Afan Wind Farm Noise Compliance Assessment, Report HM: 3202_R01_EXT1, February 2018

Table 10.25: A-Weighted Sound Power Levels (dB(A) re 1 pW) for the Nordex N90/2500 Wind Turbine

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	Warranted Plus Uncertainty
1	95.5
2	95.5
3	95.5
4	99.2
5	102.7
6	105.7
7	106.9
8	107.4
9	107.5
10	107.5
11	107.5
12	107.5

Table 10.26: Octave Band A-Weighted Sound Power Levels (dB(A) re 1 pW) at a Standardised 10 m Wind Speed of 8ms^{-1} for the Nordex N90/2500 Wind Turbine

Octave Band (Hz)	8 ms^{-1}
63	92.6
125	96.7
250	101.1
500	101.5
1000	100.0
2000	98.9
4000	94.9
8000	87.3
OVERALL	107.4

10.142 The results of the scaling are an increase in the night time predicted noise levels of 2.4 dB(A), assuming that the combined scheme is operating right up to its conditioned limit at Price Town, Nantymoel. During daytime periods an increase in the predicted noise levels of 0.5 dB(A) is applied on the assumption that the combined site is operating right up to its conditioned limit at Evanstown. The locations of these properties are as per the Pant-y-Wal Extension Noise Assessment[25].

[25] Penant Waters (PYWX) Limited, Proposed Wind Farm Extension, Noise Assessment, March 2014

Pen y Cymoedd Wind Farm

10.143 The conditioned limits within the Decision Notice[26] for the existing Pen y Cymoedd scheme and the noise limits presented in the Foel Trawsnant Environmental Statement[28] are used to determine the worst case predicted noise levels due to Pen y Cymoedd in conjunction with the existing Mynydd Bwllfa[27], Ferndale, Ffynnon Oer and Maerdy schemes along with the consented Foel Trawsnant[28] scheme using the controlling property method as described in paragraph 10.135.

10.144 Pen y Cymoedd contains a mix of Siemens SWT-3.0-108 and SWT-3.0-113 machines. Warranted acoustic data for this turbine with an allowance for uncertainty of 1 dB included, consistent with guidance provided by the manufacturer, has been used in this analysis. Details are as follows:

- hub heights of 88 & 90 m;
- rotor diameters of 108 & 113 m;
- sound power levels, L_{WA}, for standardised 10 m height wind speeds (v_{10}) as shown in **Table 10.27** (those for the SWT-3.0-108 machine are conservative at wind speeds of less than 6 ms^{-1}); and
- octave band sound power level data, at a standardised 10 m wind speed of 8 ms^{-1}, as shown in **Table 10.28.**

Table 10.27: A-Weighted Sound Power Levels (dB(A) re 1 pW) plus Uncertainty for the Siemens SWT-3.0-108 & SWT-3.0-113 Wind Turbines

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	SWT-3.0-108	SWT-3.0-113
1	105.6	91.7
2	105.6	91.7
3	105.6	91.7
4	105.6	96.1
5	105.6	100.7
6	105.6	105.1
7	107.6	106.5
8	108.0	106.5
9	108.0	106.5
10	108.0	106.5
11	108.0	106.5
12	108.0	106.5

[26] Department for Business, Energy & Industrial Strategy, Reference 12.04.09.26C, 27 February 2017

[27] Pennant Waters, Mynydd Bwllfa Wind Farm Environmental Statement, April 2009

[28] Pennant Waters (FoelT) Ltd, Foel Trawsnant Wind Farm Environmental Statement, August 2014

Table 10.28: Octave Band A-Weighted Sound Power Levels (dB(A) re 1 pW) at 8 ms^{-1} for the Siemens SWT-3.0-108 & SWT-3.0-113 Machines

Octave Band (Hz)	SWT-3.0-108	SWT-3.0-113
63	86.5	92.3
125	94.0	95.9
250	101.4	99.0
500	104.7	99.1
1000	101.4	100.1
2000	93.5	99.2
4000	82.6	96.0
8000	79.3	86.7
OVERALL	108.0	106.5

10.145 The results of the scaling are an increase in the night time predicted noise levels of 1.6 dB(A), assuming that the sites are operating right up to the ETSU-R-97 limit at Troed-y-rhiw. During daytime periods the predicted noise levels are adjusted by 0.1 dB(A) on the assumption that the sites are operating right up to the ETSU-R-97 limit at Nant-yr-hwyaid Farm. The locations of these properties are as per the Pen y Cymoedd Decision Notice[26] and the Foel Trawnant noise assessment[28].

Foel Trawsnant, Mynydd Bwllfa, Ferndale, Ffynnon Oer and Maerdy Wind Farms

10.146 The details used when considering the existing Mynydd Bwllfa, Ferndale, Ffynnon Oer and Maerdy schemes along with the consented Foel Trawsnant scheme in conjunction with the existing Pen y Cymoedd scheme are as follows:

- Turbine types, hub heights & allowances for uncertainty, consistent with guidance provided by each manufacturer, as detailed in **Table 10.29**;
- sound power levels, L_{WA}, for standardised 10 m height wind speeds (v_{10}) as shown in **Table 10.30** (data for the N90/2500 is as per **Table 10.25**); and
- octave band sound power level data, at a standardised 10 m height wind speed of 8 ms^{-1}, as shown in **Table 10.31** (data for the N90/2500 is as per **Table 10.26**).

Table 10.29: Site Details

Site Name	Turbine Type	Hub Height (m)	Uncertainty (dB)
Foel Trawsnant	Enercon E70 E4 2.3MW & 1.0MW	85	1
Mynydd Bwllfa	Nordex N90/2500	Mix of 70 & 80	2
Ferndale	Enercon E48 800kW	50	1
Ffynnon Oer	RePower MM70 2MW	58	2
Maerdy	Siemens SWT-3.0-101	94	1

Table 10.30: A-Weighted Sound Power Levels (dB(A) re 1 pW) plus Uncertainty for the Enercon E70, Enercon E48, RePower MM70 & Siemens SWT-3.0-101 Wind Turbines

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	E70 2.3MW	E70 1.0MW	Enercon E48	RePower MM70	SWT-3.0-101
1	96.1	96.1	90.9	93.5	96.4
2	96.1	96.1	90.9	93.5	96.4
3	96.1	96.1	90.9	93.5	96.4
4	96.1	96.1	90.9	93.5	96.5
5	96.1	96.1	94.3	97.5	101.4
6	101.7	99.5	98.4	101.0	106.4
7	103.6	99.5	101.3	104.2	108.2
8	105.5	99.5	102.6	106.0	109.0
9	106.5	99.5	103.2	107.0	109.0
10	106.5	99.5	103.5	107.5	109.0
11	106.5	99.5	103.5	107.5	109.0
12	106.5	99.5	103.5	107.5	109.0

Table 10.31: Octave Band A-Weighted Sound Power Levels (dB(A) re 1 pW) at 8 ms^{-1} for the Enercon E70, Enercon E48, RePower MM70 & Siemens SWT-3.0-101 Machines

Octave Band (Hz)	E70 2.3MW	E70 1.0MW	Enercon E48	RePower MM70	SWT-3.0-101
63	89.4	83.4	80.8	84.6	83.8
125	97.7	91.7	87.2	93.1	95.7
250	100.7	94.7	96.3	98.0	102.4
500	99.6	93.6	98.3	98.2	105.7
1000	97.2	91.2	96.7	100.5	102.4
2000	93.3	87.3	90.3	99.9	94.5
4000	86.5	80.5	87.0	95.7	83.6
8000	80.0	74.0	84.8	82.5	80.3
OVERALL	105.5	99.5	102.6	106.0	109.0

10.147 The predicted noise levels for daytime periods at the residential properties considered in the assessment due to the operation of the sites considered in the cumulative assessment are detailed in **Table 10.32**. Cumulative predicted noise levels during night time periods are shown in **Table 10.33**. The difference is due to the sites considered being scaled to their conditioned limits (where detailed in previous paragraphs) and the different limits applicable during day and night time periods.

10.148 The methodology used to calculate the cumulative predicted noise levels makes the assumption that the properties in question are downwind of all of the considered wind farms simultaneously which is not the case in practice. The cumulative

predicted noise levels are conservative due to the reductions in noise that would be expected when a property is situated crosswind or upwind of a noise source.

10.149 When making predictions of the cumulative noise level at a given residential property and wind speed, should any of the wind farms considered have predicted noise levels of greater than 10 dB less than the maximum predicted noise level of any of the wind farms being considered, the wind farm in question is not included as in acoustic practice it is generally accepted that where there is such a difference between the noise levels from two sources, there is no cumulative impact and the smaller source can be ignored.

Table 10.32: Cumulative Downwind Predicted Noise Levels during Daytime Periods at Nearby Residential Properties, dB(A)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H1	28.1	28.1	28.1	29.1	33.2	35.6	36.7	37.2	37.3	37.3	37.3	37.3
H2	26.2	26.2	26.2	27.7	30.6	33.4	35.0	35.6	35.7	35.7	35.7	35.7
H3	28.3	28.3	28.3	30.7	34.3	37.1	38.5	39.0	39.0	39.0	39.0	39.0
H4	30.0	30.0	30.0	31.0	35.0	37.5	38.6	39.1	39.3	39.3	39.3	39.3
H5	27.6	27.6	27.6	30.2	33.7	36.5	37.9	38.1	38.1	38.1	38.1	38.1
H6	29.9	29.9	29.9	30.2	34.5	36.7	37.3	37.8	38.1	38.1	38.1	38.1
H7	30.2	30.2	30.2	31.2	35.5	37.9	39.0	39.5	39.7	39.7	39.7	39.7
H8	27.8	27.8	27.8	28.9	32.9	35.3	36.4	36.9	37.0	37.0	37.0	37.0
H9	29.9	29.9	29.9	30.6	34.6	36.8	37.4	37.9	38.2	38.2	38.2	38.2
H10	26.3	26.3	26.3	27.0	30.8	33.3	33.9	34.6	35.0	35.0	35.0	35.0
H11	30.2	30.2	30.2	31.2	35.4	37.8	39.0	39.4	39.6	39.6	39.6	39.6
H12	28.4	28.4	28.4	28.8	32.4	35.0	36.2	37.0	37.6	37.6	37.6	37.6
H13	29.9	29.9	29.9	30.6	35.0	36.8	37.5	38.0	38.3	38.3	38.3	38.3
H14	28.1	28.1	28.1	29.1	33.2	35.6	36.7	37.1	37.3	37.3	37.3	37.3
H15	29.3	29.3	29.3	32.3	35.9	39.0	40.3	40.8	40.9	40.9	40.9	40.9

Table 10.33: Cumulative Downwind Predicted Noise Levels during Night Time Periods at Nearby Residential Properties, dB(A)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H1	28.5	28.5	28.5	29.7	33.7	36.6	37.7	37.9	38.1	38.1	38.1	38.1
H2	27.6	27.6	27.6	29.2	32.0	34.9	36.5	37.1	37.1	37.2	37.2	37.2
H3	29.6	29.6	29.6	32.3	35.4	38.6	39.9	40.4	40.5	40.5	40.5	40.5
H4	30.5	30.5	30.5	31.3	35.5	38.4	39.4	39.6	39.6	39.6	39.6	39.6
H5	28.9	28.9	28.9	31.4	34.8	37.6	39.3	39.4	39.5	39.5	39.5	39.5
H6	30.3	30.3	30.3	31.0	34.9	37.8	38.8	38.9	38.9	38.9	38.9	38.9
H7	30.7	30.7	30.7	31.6	35.7	38.7	39.8	40.0	40.0	40.0	40.0	40.0
H8	28.3	28.3	28.3	29.6	33.5	36.4	37.5	37.7	37.9	37.9	37.9	37.9
H9	30.3	30.3	30.3	31.3	34.9	37.9	38.9	39.0	39.0	39.2	39.2	39.2
H10	27.1	27.1	27.1	27.7	31.2	34.3	35.3	35.6	35.8	35.8	35.8	35.8
H11	30.7	30.7	30.7	31.6	35.7	38.7	39.7	39.9	39.9	39.9	39.9	39.9
H12	29.4	29.4	29.4	30.1	33.0	36.7	37.7	38.3	38.7	38.8	38.8	38.8
H13	30.3	30.3	30.3	31.3	35.3	37.9	38.9	39.0	39.0	39.3	39.3	39.3
H14	28.5	28.5	28.5	29.7	33.7	36.6	37.7	37.9	38.1	38.1	38.1	38.1
H15	30.9	30.9	30.9	33.7	37.1	40.6	41.9	42.4	42.5	42.5	42.5	42.5

Derived Acoustic Acceptance Criteria

10.150 A daytime lower fixed limit for the cumulative assessment has been selected through consideration of the number of noise affected residential properties, the potential impact on power output and the likely duration and level of exposure as recommended by ETSU-R-97 in the same way that this was done for the assessment of the Proposed Development alone in paragraph 10.88.

10.151 Given the greater generation capacity and therefore increased planning merit of the cumulative development, a 37.5 dB(A) daytime lower limit has been adopted in the cumulative assessment. There would be no impact on power generation should a 40 dB(A) lower limit be adopted but the trade-off against the number of affected properties and duration and level of exposure suggests a lower limit in the middle of the allowable range is appropriate.

10.152 As detailed in paragraph 10.91, the background noise survey locations inferred to be representative for each property are as shown in **Table 10.15**.

10.153 The derived noise limits for daytime and night-time periods, for each residential property, can be found in **Table 10.34** and **Table 10.35**.

Cumulative Acoustic Assessment

10.154 A comparison of the cumulative predicted noise levels with the adopted daytime noise limits for the nearby residential properties is shown in **Table 10.34**. The predicted noise levels at 1 ms^{-1} and 2 ms^{-1} have been assumed as equal to 3 ms^{-1} as a

conservative measure. The term ΔL is used to denote the difference between the predicted cumulative noise level and the recommended limit. A negative value indicates that the predicted noise level is within the limit. **Table 10.35** shows a comparison with the recommended night-time noise limits.

10.155 During daytime periods, the noise limits are predicted to be exceeded at six locations (H4, H6, H7, H9, H11 & H13) at certain wind speeds. These locations represent the villages of Blaengarw (H4, H7 & H11) and Abergwnfi (H6, H9 & H13). The maximum exceedance in Blaengarw is 1.3 dB(A) at H7 and H11, the maximum exceedance in Abergwynfi is 0.6 dB(A) at H13.

10.156 As discussed in paragraph 10.148, the cumulative predicted noise levels make the conservative assumption that the properties are downwind of all turbines simultaneously. The impact of removing this assumption to produce a more realistic assessment is discussed in the following Mitigation section.

10.157 The predicted noise levels due to the wind farms considered in the cumulative assessment, along with the daytime noise limits, at H7 and H13 are shown graphically in **Charts 11 & 12**.

10.158 Cumulative noise levels at all residential properties are within the night time noise limits at all wind speeds considered. The minimum margin of predicted noise levels below derived noise limits during daytime periods is -0.8 dB(A) at H15. The cumulative predicted noise levels and night time noise limits at H15 are shown in **Chart 13**.

10.159 **Figure 10.2** shows a cumulative noise contour plot calculated using the ISO 9613 Part 2 propagation model. The plot is provided to illustrate the cumulative noise 'footprint' and should be considered indicative only. Where properties are located such that they cannot be downwind of all turbines simultaneously, the predictions made using a downwind propagation model such as ISO 9613-2 are conservative given that reductions in noise would be expected when a property is crosswind or upwind of a noise source. The footprints for existing and consented projects are not scaled to their conditioned limits.

Table 10.34: Comparison of Downwind Cumulative Predicted Noise Levels and Daytime Noise Limits, dB(A)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1			2			3			4		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H1	28.1	37.5	-9.4	28.1	37.5	-9.4	28.1	37.5	-9.4	29.1	37.5	-8.4
H2	26.2	38.6	-12.4	26.2	39.3	-13.2	26.2	40.3	-14.1	27.7	40.9	-13.2
H3	28.3	46.8	-18.5	28.3	46.8	-18.5	28.3	46.8	-18.5	30.7	46.8	-16.1
H4	30.0	37.5	-7.5	30.0	37.5	-7.5	30.0	37.5	-7.5	31.0	37.5	-6.5
H5	27.6	38.6	-11.0	27.6	39.3	-11.7	27.6	40.3	-12.6	30.2	40.9	-10.7
H6	29.9	37.5	-7.6	29.9	37.5	-7.6	29.9	37.5	-7.6	30.2	37.5	-7.3
H7	30.2	37.5	-7.3	30.2	37.5	-7.3	30.2	37.5	-7.3	31.2	37.5	-6.3
H8	27.8	37.5	-9.7	27.8	37.5	-9.7	27.8	37.5	-9.7	28.9	37.5	-8.6
H9	29.9	37.5	-7.6	29.9	37.5	-7.6	29.9	37.5	-7.6	30.6	37.5	-6.9
H10	26.3	46.2	-19.9	26.3	46.2	-19.9	26.3	46.2	-19.9	27.0	46.2	-19.2
H11	30.2	37.5	-7.3	30.2	37.5	-7.3	30.2	37.5	-7.3	31.2	37.5	-6.3
H12	28.4	37.5	-9.1	28.4	37.5	-9.1	28.4	37.5	-9.1	28.8	37.5	-8.7
H13	29.9	37.5	-7.6	29.9	37.5	-7.6	29.9	37.5	-7.6	30.6	37.5	-6.9
H14	28.1	37.5	-9.4	28.1	37.5	-9.4	28.1	37.5	-9.4	29.1	37.5	-8.4
H15	29.3	38.6	-9.3	29.3	39.3	-10.0	29.3	40.3	-10.9	32.3	40.9	-8.6

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	5			6			7			8		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H1	33.2	37.5	-4.3	35.6	37.5	-1.9	36.7	37.5	-0.8	37.2	37.9	-0.7
H2	30.6	40.9	-10.3	33.4	41.3	-7.9	35.0	42.4	-7.4	35.6	43.3	-7.7
H3	34.3	46.8	-12.5	37.1	46.8	-9.7	38.5	46.8	-8.3	39.0	46.9	-8.0
H4	35.0	37.5	-2.5	37.5	37.5	0.0	38.6	37.7	0.9	39.1	38.9	0.2
H5	33.7	40.9	-7.3	36.5	41.3	-4.8	37.9	42.4	-4.5	38.1	43.3	-5.2
H6	34.5	37.5	-3.0	36.7	37.5	-0.8	37.3	37.5	-0.2	37.8	37.5	0.3
H7	35.5	37.5	-2.0	37.9	37.5	0.4	39.0	37.7	1.3	39.5	38.9	0.6
H8	32.9	37.5	-4.6	35.3	37.5	-2.2	36.4	37.5	-1.1	36.9	37.9	-1.0
H9	34.6	37.5	-2.9	36.8	37.5	-0.7	37.4	37.5	-0.1	37.9	37.5	0.4
H10	30.8	46.3	-15.5	33.3	46.5	-13.2	33.9	46.6	-12.7	34.6	46.6	-12.0
H11	35.4	37.5	-2.1	37.8	37.5	0.3	39.0	37.7	1.3	39.4	38.9	0.5
H12	32.4	37.5	-5.1	35.0	38.3	-3.3	36.2	39.7	-3.5	37.0	40.6	-3.6
H13	35.0	37.5	-2.5	36.8	37.5	-0.7	37.5	37.5	0.0	38.0	37.5	0.5
H14	33.2	37.5	-4.3	35.6	37.5	-1.9	36.7	37.5	-0.8	37.1	37.9	-0.8
H15	35.9	40.9	-5.1	39.0	41.3	-2.3	40.3	42.4	-2.1	40.8	43.3	-2.5

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H1	37.3	39.9	-2.6	37.3	42.7	-5.4	37.3	45.2	-7.9	37.3	47.9	-10.5
H2	35.7	44.2	-8.5	35.7	44.2	-8.5	35.7	44.2	-8.5	35.7	44.2	-8.5
H3	39.0	47.3	-8.3	39.0	48.0	-8.9	39.0	48.7	-9.7	39.0	49.6	-10.5
H4	39.3	39.8	-0.5	39.3	40.0	-0.7	39.3	40.0	-0.7	39.3	40.0	-0.7
H5	38.1	44.2	-6.0	38.1	44.2	-6.0	38.1	44.2	-6.0	38.1	44.2	-6.0
H6	38.1	37.7	0.4	38.1	39.8	-1.7	38.1	39.8	-1.7	38.1	39.8	-1.7
H7	39.7	39.8	-0.1	39.7	40.0	-0.3	39.7	40.0	-0.3	39.7	40.0	-0.3
H8	37.0	39.9	-2.9	37.0	42.7	-5.7	37.0	45.2	-8.2	37.0	47.9	-10.9
H9	38.2	37.7	0.5	38.2	39.8	-1.6	38.2	39.8	-1.6	38.2	39.8	-1.6
H10	35.0	46.5	-11.5	35.0	46.0	-11.0	35.0	46.0	-11.0	35.0	46.0	-11.0
H11	39.6	39.8	-0.2	39.6	40.0	-0.4	39.6	40.0	-0.4	39.6	40.0	-0.4
H12	37.6	41.0	-3.4	37.6	40.7	-3.1	37.6	40.7	-3.1	37.6	40.7	-3.1
H13	38.3	37.7	0.6	38.3	39.8	-1.5	38.3	39.8	-1.5	38.3	39.8	-1.5
H14	37.3	39.9	-2.6	37.3	42.7	-5.4	37.3	45.2	-7.9	37.3	47.9	-10.6
H15	40.9	44.2	-3.3	40.9	44.2	-3.3	40.9	44.2	-3.3	40.9	44.2	-3.3

The term L_p is used to denote the predicted noise level
The term ΔL is used to denote the difference between the predicted noise level and the recommended limit
Predicted exceedances are highlighted in grey

Table 10.35: Comparison of Downwind Cumulative Predicted Noise Levels and Night Time Limits, dB(A)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1			2			3			4		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H1	28.5	43.0	-14.5	28.5	43.0	-14.5	28.5	43.0	-14.5	29.7	43.0	-13.3
H2	27.6	43.0	-15.4	27.6	43.0	-15.4	27.6	43.0	-15.4	29.2	43.0	-13.8
H3	29.6	45.6	-16.0	29.6	45.6	-16.0	29.6	45.6	-16.0	32.3	45.6	-13.3
H4	30.5	43.0	-12.5	30.5	43.0	-12.5	30.5	43.0	-12.5	31.3	43.0	-11.7
H5	28.9	43.0	-14.1	28.9	43.0	-14.1	28.9	43.0	-14.1	31.4	43.0	-11.6
H6	30.3	43.0	-12.7	30.3	43.0	-12.7	30.3	43.0	-12.7	31.0	43.0	-12.0
H7	30.7	43.0	-12.3	30.7	43.0	-12.3	30.7	43.0	-12.3	31.6	43.0	-11.4
H8	28.3	43.0	-14.7	28.3	43.0	-14.7	28.3	43.0	-14.7	29.6	43.0	-13.4
H9	30.3	43.0	-12.7	30.3	43.0	-12.7	30.3	43.0	-12.7	31.3	43.0	-11.7
H10	27.1	46.4	-19.3	27.1	46.4	-19.3	27.1	46.4	-19.3	27.7	46.4	-18.7
H11	30.7	43.0	-12.3	30.7	43.0	-12.3	30.7	43.0	-12.3	31.6	43.0	-11.4
H12	29.4	43.0	-13.6	29.4	43.0	-13.6	29.4	43.0	-13.6	30.1	43.0	-12.9
H13	30.3	43.0	-12.7	30.3	43.0	-12.7	30.3	43.0	-12.7	31.3	43.0	-11.7
H14	28.5	43.0	-14.5	28.5	43.0	-14.5	28.5	43.0	-14.5	29.7	43.0	-13.3
H15	30.9	43.0	-12.1	30.9	43.0	-12.1	30.9	43.0	-12.1	33.7	43.0	-9.3

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	5			6			7			8		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H1	33.7	43.0	-9.3	36.6	43.0	-6.4	37.7	43.0	-5.3	37.9	43.0	-5.1
H2	32.0	43.0	-11.0	34.9	43.0	-8.1	36.5	43.0	-6.5	37.1	43.2	-6.1
H3	35.4	45.6	-10.2	38.6	45.6	-7.1	39.9	45.7	-5.8	40.4	46.3	-5.8
H4	35.5	43.0	-7.5	38.4	43.0	-4.6	39.4	43.0	-3.6	39.6	43.0	-3.4
H5	34.8	43.0	-8.2	37.6	43.0	-5.4	39.3	43.0	-3.7	39.4	43.2	-3.8
H6	34.9	43.0	-8.1	37.8	43.0	-5.2	38.8	43.0	-4.2	38.9	43.0	-4.1
H7	35.7	43.0	-7.3	38.7	43.0	-4.3	39.8	43.0	-3.2	40.0	43.0	-3.0
H8	33.5	43.0	-9.5	36.4	43.0	-6.6	37.5	43.0	-5.5	37.7	43.0	-5.3
H9	34.9	43.0	-8.1	37.9	43.0	-5.1	38.9	43.0	-4.1	39.0	43.0	-4.0
H10	31.2	46.5	-15.3	34.3	46.5	-12.2	35.3	46.5	-11.2	35.6	46.4	-10.8
H11	35.7	43.0	-7.3	38.7	43.0	-4.3	39.7	43.0	-3.3	39.9	43.0	-3.1
H12	33.0	43.0	-10.0	36.7	43.0	-6.3	37.7	43.0	-5.3	38.3	43.0	-4.7
H13	35.3	43.0	-7.7	37.9	43.0	-5.1	38.9	43.0	-4.1	39.0	43.0	-4.0
H14	33.7	43.0	-9.3	36.6	43.0	-6.4	37.7	43.0	-5.3	37.9	43.0	-5.1
H15	37.1	43.0	-5.9	40.6	43.0	-2.4	41.9	43.0	-1.1	42.4	43.2	-0.8

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	9			10			11			12		
	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL	L_p	Limit	ΔL
H1	38.1	43.0	-4.9	38.1	43.0	-4.9	38.1	45.3	-7.2	38.1	45.3	-7.2
H2	37.1	43.8	-6.6	37.2	43.8	-6.6	37.2	43.8	-6.6	37.2	43.8	-6.6
H3	40.5	47.0	-6.6	40.5	48.0	-7.5	40.5	48.9	-8.5	40.5	48.9	-8.5
H4	39.6	43.0	-3.4	39.6	43.0	-3.4	39.6	43.0	-3.4	39.6	43.0	-3.4
H5	39.5	43.8	-4.3	39.5	43.8	-4.3	39.5	43.8	-4.3	39.5	43.8	-4.3
H6	38.9	43.0	-4.1	38.9	43.0	-4.1	38.9	43.0	-4.1	38.9	43.0	-4.1
H7	40.0	43.0	-3.0	40.0	43.0	-3.0	40.0	43.0	-3.0	40.0	43.0	-3.0
H8	37.9	43.0	-5.1	37.9	43.0	-5.1	37.9	45.3	-7.5	37.9	45.3	-7.5
H9	39.0	43.0	-4.0	39.2	43.0	-3.8	39.2	43.0	-3.8	39.2	43.0	-3.8
H10	35.8	46.2	-10.4	35.8	45.7	-9.9	35.8	45.7	-9.9	35.8	45.7	-9.9
H11	39.9	43.0	-3.1	39.9	43.0	-3.1	39.9	43.0	-3.1	39.9	43.0	-3.1
H12	38.7	43.0	-4.3	38.8	43.0	-4.2	38.8	43.0	-4.2	38.8	43.0	-4.2
H13	39.0	43.0	-4.0	39.3	43.0	-3.7	39.3	43.0	-3.7	39.3	43.0	-3.7
H14	38.1	43.0	-4.9	38.1	43.0	-4.9	38.1	45.3	-7.3	38.1	45.3	-7.3
H15	42.5	43.8	-1.3	42.5	43.8	-1.3	42.5	43.8	-1.3	42.5	43.8	-1.3

The term L_p is used to denote the predicted noise level
The term ΔL is used to denote the difference between the predicted noise level and the recommended limit

Mitigation

10.160 Turbine management has been considered to ensure that the cumulative noise levels comply with the noise limits during daytime periods at all properties and all wind speeds. This involves reducing the amount of noise from the Proposed Development by operating selected turbines in reduced noise mode in certain conditions.

10.161 The Vestas V105 3.6MW is an up-rated version of the 3.45MW machine which has three reduced modes of operation whereby the pitch of the turbine blades can be altered in a trade-off between power production and noise reduction. Acoustic emission data for the available modes, referenced to 97.4 m hub height, is shown in **Table 10.36**. A 2 dB(A) allowance for measurement uncertainty has been included, consistent with the information provided by the manufacturer.

Table 10.36: A-Weighted Sound Power Levels (dB(A) re 1 pW) for Reduced Noise Modes

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	Mode 1	Mode 2	Mode 3
1	95.1	95.1	95.1
2	95.1	95.1	95.1
3	95.1	95.1	95.1
4	97.0	97.0	97.0
5	101.0	101.0	100.8
6	103.9	103.6	102.1
7	104.7	104.2	102.4
8	104.7	104.2	102.4
9	104.7	104.2	102.4
10	104.7	104.2	102.4
11	104.7	104.2	102.4
12	104.7	104.2	102.4

10.162 A turbine management strategy has been designed at the wind speeds where the daytime limits are predicted to be exceeded in the cumulative assessment. Operating the turbines that make up the Development in the modes detailed in **Table 10.37** is predicted to result in the limits being met. For all other wind speeds and during night time periods the turbines would operate in the unconstrained Mode 0.

Table 10.37: Suggested Operational Modes during Daytime Periods at Specified Wind Speeds

Turbine	6 ms^{-1}	7 ms^{-1}	8 ms^{-1}	9 ms^{-1}
T1	Mode 2	Mode 3	Mode 3	Mode 3
T2	Mode 0	Mode 1	Mode 3	Mode 3
T3	Mode 0	Mode 0	Mode 0	Mode 0
T4	Mode 0	Mode 0	Mode 0	Mode 0
T5	Mode 0	Mode 0	Mode 0	Mode 0
T6	Mode 0	Mode 0	Mode 0	Mode 0
T7	Mode 0	Mode 3	Mode 2	Mode 1

10.163 The impact of the noise management strategy described on the predicted noise levels from the Proposed Development, along with the cumulative predicted noise levels, at H7 & H13 can be seen in **Charts 14 & 15**[29]. The daytime noise limit is considered to be met in the cumulative scenario due to the reduction in the predicted noise levels from the Proposed Development.

[29] The presented noise management strategy does not reduce the predicted noise levels from the Proposed Development to less than the total ETSU-R-97 noise limit – 10 dB(A). Decreasing the noise levels from the Proposed Development further, whilst possible, would not provide significant additional acoustic benefit at the properties in question but would be increasingly significant in terms of the impact on power production. For the purposes of the cumulative assessment the limit is deemed to be met despite marginal paper-based exceedances of up to 0.2 dB(A) at houses H6, H9 & H13 at wind speeds of 8 and 9 ms^{-1}.

10.164 The presented noise management strategy is designed such that the limit would be met assuming the properties in question are located downwind of all of the projects considered in the cumulative assessment at all times. The strategy is conservative in that the amount of noise management required is likely to reduce for certain wind directions, as noise levels will be lower when properties are located upwind or crosswind of a turbine.

10.165 Rather than making the conservative assumption that properties are downwind of all of the turbines considered in the cumulative assessment simultaneously, a more detailed assessment, including detailed directional calculations, has been undertaken. The directional attenuation factors applied, detailed in **Table 11.38**, are consistent with the recommendations of the IoA GPG, with reductions in noise of 2 dB(A) when a receiver is crosswind, and 10 dB(A) when a receiver is upwind of a noise source respectively and a polynomial interpolation in the intermediate directions.

Table 11.38: Directional Attenuation Factors

Directional Offset from Directly Downwind (º)	Directional Attenuation Factor (dB)
0	0.0
30	0.0
60	0.0
90	-2.0
120	-6.7
150	-9.3
180	-10.0
210	-9.3
240	-6.7
270	-2.0
300	0.0
330	0.0

10.166 The IoA GPG goes on to state that such reductions would only come into play gradually at distances of between five and ten tip heights. As such, the attenuation factors applied have been adjusted by the separation distance between the source and receiver accordingly.

10.167 The predicted noise levels for each site are scaled to the consented noise limits using the controlling property method recommended by the IoA GPG for each wind direction sector.

10.168 The results of the cumulative directional assessment show that the noise limits are met at all but four locations (H4, H7, H11 & H13) during daytime periods. The results

confirm the conservatism of the non-directional assessment in that exceedances are no longer predicted at H6 and H9 and the exceedances at H4, H7, H11 and H13 occur in certain wind directions only. **Chart 4** can be referred to for an appreciation of how often the wind is expected to be from each direction sector at the site. It shows that the most commonly occurring wind directions are from the west i.e. direction sectors of 240 and 270 degrees.

10.169 At H4 (Bryn Eglur), the daytime limit is predicted to be exceeded for direction sectors of 330, 0, 30 and 60 degrees only as per **Chart 16**. The maximum exceedance is predicted to be 1.1 dB(A)[30] for the 330 degree sector at a wind speed of 7 ms^{-1}. To illustrate the variation in the predicted cumulative noise level with wind direction, the cumulative noise levels are expected to be 3.8 dB(A) below the limit in the 150 and 180 degree sectors at 7 ms^{-1}. The contribution of each of the projects considered in the cumulative assessment to the cumulative noise level at the wind speed where the maximum exceedance occurs can be seen in **Chart 17**.

10.170 At H7 (14 Pwllgarn Terrace) and H11 (Blaengarw), the daytime limit is predicted to be exceeded for direction sectors of 300, 330, 0, 30, 60 and 90 degrees only as illustrated in **Charts 18 & 20**. The maximum exceedance is predicted to be 1.4 dB(A)[30] for the 330 degree sector at a wind speed of 7 ms^{-1}. To illustrate the variation in the predicted cumulative noise level with wind direction, the cumulative noise levels are expected to be 3.4 dB(A) below the limit at H7 and 3.5 dB(A) below the limit at H11 in the 150 degree sector at 7 ms^{-1}. The contribution of each of the projects considered in the cumulative assessment at the wind speed where the maximum exceedance occurs can be seen in **Charts 19 & 21**.

10.171 At H13 (40 High Street), the daytime limit is predicted to be exceeded for the 90 degree direction sector only as per **Chart 22**. The maximum exceedance is predicted to be 0.2 dB(A) at a wind speed of 8 ms^{-1}. To illustrate the variation in the predicted cumulative noise level with wind direction, the cumulative noise levels are expected to be 3.2 dB(A) below the limit in the 330 and 0 degree sectors at 8 ms^{-1}. The contribution of each of the projects considered in the cumulative assessment at the wind speed where the maximum exceedance occurs can be seen in **Chart 23**.

10.172 The directional assessment has shown that the daytime noise limit is not expected to be exceeded in certain direction sectors, including those expected to occur most often, such that noise management would not be required in these sectors. A more detailed directional noise management strategy could therefore be designed to

[30] The maximum predicted exceedances at H4, H7 and H11 in the directional assessment are 0.1-0.2 dB(A) greater than those predicted in the non-directional assessment. This is the result of two factors: 1) no noise management would be required for the Llynfi Afan scheme to meet its conditioned noise limit in some direction sectors such that the predicted noise levels due to this project are greater in the directional assessment than in the non-directional assessment (where noise management is required) in these direction sectors. 2) The Pen y Cymoedd, Mynydd Bwllfa, Ferndale, Ffynnon Oer, Maerdy and Foel Trawsnant schemes are grouped together in the directional assessment so are more likely to be considered in the calculation (i.e. be within 10 dB of the maximum predicted noise level due to any of the sites considered) than when compared to this level on their own as they are in the non-directional assessment.

reduce the predicted noise levels due to the Proposed Development in only the direction sectors where this is identified as necessary.

Cumulative Construction Noise Assessment

10.173 Any noise due to the construction of the other wind farms considered in the cumulative operational noise assessment is unlikely to be ongoing at the same time as the construction of the Proposed Development. Only the consented Foel Trawsnant scheme has yet to be constructed and it is located 6 km west of the Proposed Development. In the event that construction does occur at the same time, the activities would be far enough away from each other so as not to have a cumulative impact.

Summary

10.174 The acoustic impact for the operation of the Proposed Development on nearby residential properties has been assessed in accordance with the guidance on wind farm noise as issued in the DTI publication "The Assessment and Rating of Noise from Wind Farms", otherwise known as ETSU-R-97, and Institute of Acoustics Good Practice Guide (IoA GPG), as recommended for use by Welsh planning policy.

10.175 To establish baseline conditions, background noise surveys were carried out at three nearby properties and the measured background noise levels, along with those from four previous survey locations, used to determine appropriate noise limits as specified by ETSU-R-97 and the IoA GPG.

10.176 Operational noise levels were predicted using a noise propagation model, the proposed turbine locations, terrain data and assumed turbine emission data. The predicted noise levels are within noise limits derived in accordance with ETSU-R-97 at all properties at all considered wind speeds when the Proposed Development is considered on its own.

10.177 A construction noise assessment carried out in accordance with BS 5228-1:2009 "Noise control on construction and open sites Part 1 - Noise" indicates that the predicted noise levels likely to be experienced at representative residential properties are below relevant construction noise criteria except for works taking place on Saturday afternoons between 1300 and 1900 for which appropriate mitigation measures have been identified.

10.178 An assessment of the predicted levels of vibration at nearby properties due to blasting at the proposed borrow pits indicates that the probability of adverse comment is low. Vibration and air overpressure due to blasting are not expected to have a significant impact on nearby residents should the mitigation measures described within be adopted.

10.179 A cumulative operational noise assessment was completed to determine the potential impact of the Proposed Development in conjunction with other existing and

consented schemes located nearby. The cumulative predicted noise levels, with appropriate mitigation measures applied to the Proposed Development, are within noise limits derived in accordance with ETSU-R-97 at all properties at all considered wind speeds. A more detailed directional assessment demonstrates that mitigation measures would be necessary in certain direction sectors only.

10.180 The potential impact of the Proposed Development, along with the mitigation proposed and any residual impact, is summarised in **Table 10.39**.

Table 10.39: Summary of Potential Impacts of the Proposed Development , Mitigation and Residual Impacts

Potential Impact	Mitigation Proposed	Means of Implementation	Outcome/ Residual Impact
Operational Noise			
Potential for operational noise to exceed daytime limit in cumulative scenario	Noise management to meet daytime limit at wind speeds and direction sectors where necessary	Operation of certain turbines in reduced noise mode	Impact deemed acceptable as cumulative wind farm noise levels meet limits specified by relevant guidance
Construction Noise			
Potential for construction noise to exceed recommended limit for Saturdays 1300-1900	Reduce construction noise levels to comply with relevant criteria	Reduce number of construction activities occurring simultaneously, restrict distance of construction activities from identified properties or reduce construction traffic as required	No significant impacts expected

Glossary

A-weighting

A frequency-response function providing good correlation with the sensitivity of the human ear.

Broadband Noise

Noise which covers a wide range of frequencies (see Frequency).

Decibel, dB(A)

The decibel (dB) is a logarithmic unit used in acoustics to quantify sound levels relative to a 0 dB reference (e.g. a sound pressure level of $2*10^{-5}$ Pa or 20 µPa). The 'A' signifies A-weighting.

Equivalent Continuous Sound Level (L_{eq})

The equivalent continuous sound level is a notional steady noise level, which over a given time would provide the same energy as the intermittent noise.

Frequency

Refers to how quickly the air vibrates, or how close the sound waves are to each other and is measured in cycles per second, or Hertz (Hz). The lowest frequency audible to humans is 20 Hz and the highest is 20,000 Hz. The human ear is most sensitive to the 1 kHz, 2 kHz and 4 kHz octave bands and much less sensitive at lower audible frequencies.

Frequency Spectrum

Description of the sound pressure level of a source as a function of frequency.

Percentile Sound Level (L_{90})

Sound pressure level exceeded for 90% of the time for any given time interval. For example, $L_{(A)90,10min}$ means the A-weighted level that is exceeded for 90% of a ten minute interval. This indicates the noise levels during quieter periods, or the background noise level. It represents the lower estimate of the prevailing noise level and is useful for excluding such effects as aircraft or dogs barking on background noise levels.

Noise Emission

The noise energy emitted by a source (e.g. a wind turbine).

Noise Immission

The sound pressure level detected at a given location (e.g. nearest dwelling).

Octave Band

Range of frequencies between one frequency ($f_0*2^{-1/2}$) and a second frequency ($f_0*2^{+1/2}$). The quoted centre frequency of the octave band is f_0.

Sound Power Level (L_W)

Sound power level is the acoustic power radiated from a sound source and is independent of the surroundings. It is a logarithmic measure in comparison to a reference level (10^{-12} Watts or 1 pW).

Sound Pressure Level (L_P)

A logarithmic measure of the effective sound pressure of a sound relative to a reference value which is for minimum audible field conditions ($20*10^{-6}$ Pa or 20 µPa).

Third Octave Band

The range of frequencies between one frequency ($f_0*2^{-1/6}$) and a second frequency equal to ($f_0*2^{+1/6}$). The quoted centre frequency of the third octave band is f_0.

Tonal Noise

A noise that contains a noticeable or discrete, continuous note and includes noises such as hums, hisses, screeches.