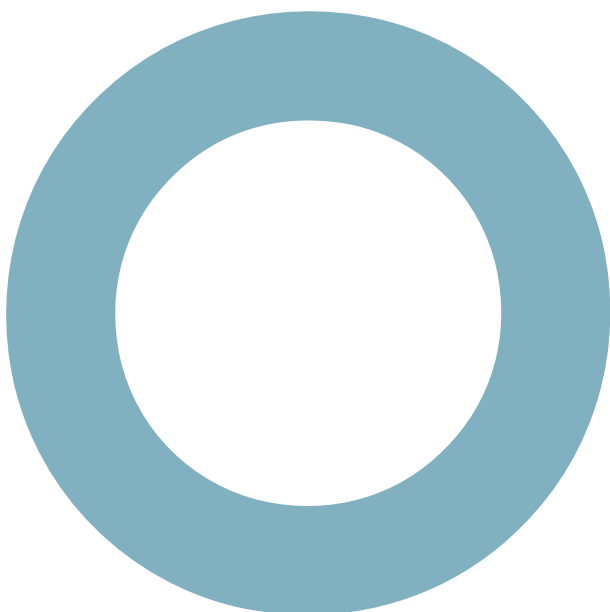


Mynydd Fforch Dwm Wind Farm.

Environmental noise assessment.

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Contents.

Audit sheet.	2
Executive Summary	4
1. Introduction	5
2. Policy and Guidance Documents	5
2.1 Planning Policy and Advice Relating to Noise	5
3. Scope and Methodology	7
3.1 Methodology for Assessing Construction Noise and Vibration	7
3.2 Methodology for Assessing Operational Noise	8
3.3 Construction Noise and Vibration Criteria	10
3.4 Operational Noise Criteria	11
3.5 Consultation	12
4. Baseline	14
4.1 General Description	14
4.2 Details of the Baseline Background Noise Data	14
4.3 Measured Background Noise Levels	16
5. Noise Impact Assessment	17
5.1 Predicted Construction Noise Levels	17
5.2 Decommissioning Noise	22
5.3 Operational Wind Turbine Emissions Data	22
5.4 Choice of Wind Farm Operational Noise Propagation Model	23
5.5 Predicted Wind Farm Operational Noise Immission Levels	23
5.6 ETSU-R-97 assessment	25
5.7 Additional cumulative assessment	27
5.8 Wind turbines: low-frequency Noise, Vibration and Amplitude Modulation	28
5.9 Substation and solar operational noise	28
6. Summary of Key Findings and Conclusions	30
Annex A - General Approach to Noise Assessment & Glossary	31
Annex B – Location Maps and Turbine Coordinates	49
Annex C – Background Noise and Noise Limits	57

Executive Summary

Hoare Lea (HL) have been commissioned by Naturalis Energy Developments Ltd to undertake a noise assessment for the construction and operation of the proposed Mynydd Fforch Dwm Wind Farm. Noise will be emitted by equipment and vehicles used during construction and decommissioning of the wind farm and by the turbines during operation. The level of noise emitted by the sources and the distance from those sources to the receiver locations are the main factors determining levels of noise at receptor locations.

Construction Noise

Construction noise has been assessed by a desk-based study of a potential construction programme and by assuming the proposed development is constructed using standard and common methods. Noise levels have been calculated for receiver locations closest to the areas of work and compared with guideline and baseline values. Construction noise, by its very nature, tends to be temporary and highly variable and therefore much less likely to cause adverse effects. Factors including in particular the restrictions of hours of working have been taken into consideration. It is concluded that noise generated through construction activities would generally have negligible to minor impact.

The potential noise and vibration from site access track construction works at the closest property in Tonmawr could however represent a moderate impact. Several management and mitigation measures have been proposed to minimise this and reduce the impact to a minor magnitude.

De-commissioning is likely to result in less noise than during construction of the Proposed Development. The construction phase has been considered to have minor noise impacts (following mitigation), therefore de-commissioning will, in the worst case, also have minor noise impacts.

Operational Noise

Operational turbines emit noise from the rotating blades as they pass through the air. This noise can sometimes be described as having a regular 'swish'. The amount of noise emitted tends to vary depending on the wind speed. When there is little wind the turbine rotors will turn slowly and produce lower noise levels than during high winds when the turbine reaches its maximum output and maximum rotational speed. Background noise levels at nearby properties will also change with wind speed, increasing in level as wind speeds rise due to wind in trees and around buildings, etc.

Noise levels from operation of the turbines have been predicted for those locations around the site most likely to be affected by noise. Surveys have been performed to establish existing baseline noise levels at a number of these properties. Noise limits have been derived from historical data about the existing noise environment following the method stipulated in national planning guidance. Predicted noise levels take full account of the potential combination of the noise from the Proposed Development along with Pen y Cymoedd Wind Farm and Ffynnon Oer Wind Farm. Other, more distant wind farms were not considered in detail as they do not make an acoustically relevant contribution to cumulative noise levels.

Predicted operational noise levels have been compared to the limit values to demonstrate that turbines of the type and size which would be installed can operate within the limits so derived. At some locations under some wind conditions and for a certain proportion of the time, the wind farm noise may be audible, which could represent an adverse impact. It was however concluded that, in all cases, operational noise levels from the wind farm will be within levels recommended in national guidance for wind energy schemes.

Noise from the proposed substation and solar area is likely to be at low levels at the nearest properties, representing a negligible impact.

This Executive Summary contains an overview of the noise assessment and its conclusions. No reliance should be placed on the content of this Executive Summary until this report has been read in its entirety.

1. Introduction

- 1.1 This report presents an assessment of the potential construction and operational noise impacts of the Mynydd Fforch Dwm Wind Farm (the Proposed Development) on the residents of nearby dwellings. The assessment considers both the construction and operation of the Proposed Development and also the likely impacts of its de-commissioning. Assessment of operational noise accounts for the cumulative total of the Proposed Development as well as other wind farms nearby. Other wind farms considered were those closest and consisted of two operational schemes: the Pen y Cymoedd Wind Farm (east of the Site) and the Fynnon Oer Wind Farm (approximately 1 kilometre further east of the Proposed Development). Other, more distant wind farms, such as the proposed Melin Court Wind Farm or Foel Trawsant Wind Farm and other developments located further away, were not assessed in detail because their potential noise contribution was considered negligible (see Sections 5.3 and 5.7).
- 1.2 Noise and vibration which arises from the construction of a wind farm is a factor which should be taken into account when considering the Proposed Development. However, in assessing the impacts of construction noise, it is accepted that the associated works are of a temporary nature. The main work locations for construction of the turbines are distant from nearest noise sensitive residences and are unlikely to cause strong impacts. The construction and use of access tracks may, however, occur at lesser separation distances. Assessment of the temporary impacts of construction noise is primarily aimed at understanding the need for dedicated management measures and, if so, the types of measures that are required. Further details of relevant working practices, traffic routes, and proposed working hours are described in the Proposed Scheme Description and Transport and Access chapters of the Environmental Impact Assessment reports.
- 1.3 Once constructed and operating, wind turbines may emit two types of noise. Firstly, aerodynamic noise is a 'broad band' noise, sometimes described as having a characteristic modulation, or 'swish', which is produced by the movement of the rotating blades through the air. Secondly, mechanical noise may emanate from components within the nacelle of a wind turbine. This is a less natural sounding noise which is generally characterised by its tonal content. Traditional sources of mechanical noise comprise gearboxes or generators. Due to the acknowledged lower acceptability of tonal noise in otherwise 'natural' noise settings such as rural areas, modern turbine designs have evolved to minimise mechanical noise radiation from wind turbines. Aerodynamic noise tends to be perceived when the wind speeds are low, although at very low wind speeds the blades do not rotate or rotate very slowly and so, at these wind speeds, negligible aerodynamic noise is generated. In higher winds, aerodynamic noise is generally masked by the normal sound of wind blowing through trees and around buildings. The level of this natural 'masking' noise relative to the level of wind turbine noise determines the subjective audibility of the wind farm. The relationship between wind turbine noise and the naturally occurring masking noise at residential dwellings lying around the Proposed Development will therefore generally form the basis of the assessment of the levels of noise against accepted standards.
- 1.4 An overview of environmental noise assessment and a glossary of noise terms are provided in Annex A.

2. Policy and Guidance Documents

2.1 Planning Policy and Advice Relating to Noise

- 2.1.1 Current government planning advice to Local Authorities in Wales concerning noise takes two forms. General guidance is provided by 'Planning Policy Wales' (PPW, February 2021)¹. This guidance document is then supplemented by 'Technical Advice Note (Wales) 11: Noise'² (TAN11). The

1 Planning Policy Wales, Edition 11, February 2021.

2 Planning Guidance (Wales), Technical Advice Note (Wales) 11, Noise, 1997.

introduction to TAN11 sets out the importance of appropriately considering noise in planning applications and states 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.'

- 2.1.2 Annex B of TAN11 provides guidance on the assessment of environmental noise from different sources. Paragraph B19 of the Annex makes direct reference to noise from wind turbines and states:

'Detailed guidance on noise from wind turbines is contained in Planning Guidance (Wales), Technical Advice Note (Wales) 8 'Renewable Energy', 1996.'

- 2.1.3 The 1996 version of TAN8 referenced in TAN11 and its subsequent update in 2005 have now been superseded by Future Wales: the National Plan 2040³. This sets out several Pre-Assessed Areas for Wind Energy which were assessed as “capable of accommodating development in an acceptable way” and explains that certain large-scale energy developments will be considered as Developments of National Significance and determined at the national level. Policy 18 of the National Plan includes several criteria for such large-scale developments, including the requirement that there should not be “unacceptable adverse impacts by way of shadow flicker, noise [...]”. It also notes that the “cumulative impacts of existing and consented renewable energy schemes should also be considered.”

- 2.1.4 Planning Policy Wales explains that “impact on health and amenity” should be considered in relation to potentially polluting development. In relation to energy developments, it specifically notes that:

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

- 2.1.5 The basic aim of ETSU-R-97⁴ is to provide:

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

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

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

- 2.1.7 The recommendations contained in ETSU-R-97 provide a robust basis for assessing the noise implications of a wind farm. ETSU-R-97 has become the accepted standard for such developments within the UK. This methodology has therefore been adopted for the present assessment and is described in greater detail below. The guidance on good practice on the application of ETSU-R-97, which is referenced in PPW, has been provided by the Institute of Acoustics⁵ (IOA Good Practice Guide or GPG): this will therefore be referenced in the present assessment.

- 2.1.8 For assessing noise from non-wind turbines sources associated with the Proposed Development, such as fixed plant associated with the substation and solar elements, TAN11 advises the use of the BS 4142

³ Future Wales: the National Plan 2040, February 2021.

⁴ ETSU-R-97, The Assessment and Rating of Noise from Wind Farms, Final Report for the Department of Trade & Industry, September 1996. The Working Group on Noise From Wind Turbines

⁵ A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, M. Cand, R. Davis, C. Jordan, M. Hayes, R. Perkins, Institute of Acoustics, May 2013.

standard. Although TAN 11 references the 1990 version of the standard, the more recent 2019 version⁶ is now applicable.

- 2.1.9 In Wales there are two legislative instruments which address the effects of environmental noise with regard to construction noise and vibration, and nuisance. The Environmental Protection Act 1990⁷ (EPA) and the Control of Pollution Act 1974⁸ (CoPA). The CoPA provides two means of controlling construction noise and vibration. Section 60 provides the Local Authority with the power to impose at any time operating conditions on the development site. Section 61 allows the developer to negotiate a set of operating procedures with the Local Authority prior to commencement of site works.
- 2.1.10 To assess construction noise and vibration, Annex B of TAN11 refers to BS 5228⁹ 'Noise control on construction and open sites', Parts 1 to 4, as the appropriate source of guidance. This standard has been updated since TAN11 was published. The most recent update was published in January 2009 and consolidates all previous parts of the standard into BS 5228-1:2009 (amended 2014)¹⁰ (BS 5228-1) for airborne noise and BS 5228-2:2009 (amended 2014)¹¹ (BS 5228-2) for ground borne vibration. These updated standards supersede all previous versions and have therefore been adopted as the relevant versions upon which to base this assessment.
- 2.1.11 BS 5228-1 provides guidance on a range of considerations relating to construction noise including the legislative framework, general control measures, example methods for estimating construction noise levels and example criteria which may be considered when assessing the magnitude of the impacts. Similarly, BS 5228-2 provides general guidance on legislation, prediction, control and assessment criteria for construction vibration.
- 2.1.12 TAN11 does not deal specifically with noise from stone extraction from borrow pits. However, Welsh planning guidance on surface mineral extraction provides guidance that is relevant to the types of mineral extraction activity associated with site construction works. Reference should be made to Minerals Technical Advice Note (Wales) 1: Aggregates (MTAN1)¹². BS 5228-1 and BS 5228-2 also provide guidance relating to surface mineral extraction including the assessment of noise and vibration impacts associated with quarry blasting. BS 6472-2 2008¹³ gives similar guidance on assessing vibration from blasting associated with mineral extraction.

3. Scope and Methodology

3.1 Methodology for Assessing Construction Noise and Vibration

- 3.1.1 Construction works include both moving sources and static sources. The moving sources normally comprise mobile construction plant and Heavy Goods Vehicles (HGVs). The static sources include construction plant temporarily placed at fixed locations and in some instances noise arising from blasting activities where rock is to be worked through.
- 3.1.2 The analysis of construction noise has been undertaken in accordance with BS 5228-1 which provides methods for predicting construction noise levels on the basis of reference data for the emissions of typical construction plant and activities. These methods include for the calculation of construction

6 British Standard 4142: 2014+A1 2019 Method for rating and assessing industrial and commercial sound. British Standards Institution. 2019.

7 Environmental Protection Act, Part III, HMSO, 1990.

8 Control of Pollution Act, Part III, HMSO, 1974.

9 BS 5228 Noise and Vibration Control on Construction and Open Sites.

10 BS 5228-1:2009-A:2014 'Code of practice for noise and vibration control on construction and open sites – Part 1: Noise'.

11 BS 5228-2:2009-A:2014 'Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration'.

12 Minerals Planning Policy (Wales), Minerals Technical Advice Note (Wales) 1: Aggregates, National Assembly for Wales, 2004

13 BS 6472-2:2008:Guide to evaluation of human exposure to vibration in buildings - Part 2: Blast-induced vibration.

traffic along access tracks and haul routes and also for construction activities at fixed locations such as the bases of turbines, site compounds or sub stations.

- 3.1.3 The BS 5228 calculated levels are then compared with absolute noise limits for temporary construction activities which are commonly regarded as providing an acceptable level of protection from the short-term noise levels associated with construction activities.
- 3.1.4 Separate consideration is also given to the possible noise impacts of construction related traffic passing to and from the site along local surrounding roads. In considering potential noise levels associated with construction traffic movement on public roads, reference is made to the accepted UK prediction methodology provided by 'Calculation of Road Traffic Noise'¹⁴ (CRTN).
- 3.1.5 The nature of works and distances involved in the construction of a wind farm are such that the risk of non-negligible impacts relating to ground borne vibration are generally very low. Occasional momentary vibration can arise when heavy vehicles pass dwellings at very short separation distances, but again this is not sufficient to constitute a risk of moderate/major impacts in this instance. However, some activities which could generate vibration may occur in proximity to some of the dwellings and the potential impacts will be considered in this report.

3.2 Methodology for Assessing Operational Noise

- 3.2.1 The ETSU-R-97 assessment procedure specifies that noise limits should be set relative to existing background noise levels at the nearest properties and that these limits should reflect the variation in both turbine source noise and background noise with wind speed. The wind speed range which should be considered is between the cut-in speed (the speed at which the turbines begin to operate) for the turbines and 12 m/s (43.2 km/h), where all wind speeds are referenced to a ten metre measurement height (in accordance with the IOA GPG guidance).
- 3.2.2 Separate noise limits apply for the day-time and night-time. Day-time limits are chosen to protect a property's external amenity whilst outside their dwellings in garden areas and night-time limits are chosen to prevent sleep disturbance indoors. Absolute lower limits, different for day-time and night-time, are applied where the line of best-fit representation of the measured background noise levels equates to very low levels (< 30 dB(A) to 35 dB(A) for day-time, and < 38 dB(A) during the night).
- 3.2.3 The day-time noise limit is derived from background noise data measured during the 'quiet periods of the day' defined in ETSU-R-97: these comprise weekday evenings (18:00 to 23:00), Saturday afternoons and evenings (13:00 to 23:00) and all day and evening on Sundays (07:00 to 23:00). Multiple samples of ten-minute background noise levels using the $LA_{90,10min}$ measurement index are measured contiguously over a wide range of wind speed conditions (a definition of the $LA_{90,10min}$ index is given in Annex A). The measured noise levels are then plotted against the simultaneously measured wind speed data and a 'best-fit' curve is fitted to the data to establish the background noise level as a function of wind speed. The ETSU-R-97 day-time noise limit is then set to the greater of either: a level 5 dB(A) above the best-fit curve to the background noise data over a 0-12 m/s wind speed range or a fixed level in the range 35 dB(A) to 40 dB(A). The precise choice of the fixed lower limit within the range 35 dB(A) to 40 dB(A) depends on a number of factors: the number of noise affected properties, the likely duration and level of exposure and the consequences of the choice on the potential power generating capability of the wind farm.
- 3.2.4 ETSU-R-97 clearly indicates that the day-time limit is intended to lie within the range from 35 dB(A) to 40 dB(A). Therefore, one can conclude that there must be projects where 35 dB(A) is appropriate and conversely, projects where 40 dB(A) is appropriate. Within ETSU-R-97 there is a specific example: *"A single wind turbine causing noise levels of 40 dB(A) at several nearby residences would have less planning merit (...) than 30 wind turbines also causing the same amount of noise at several nearby*

14 Calculation of Road Traffic Noise, HMSO Department of Transport, 1988.

residences". Therefore, where a project offers relatively low power generating potential, the day-time limit should naturally tend towards the lower end of the range, unless the number of noise affected properties and the extent to which those properties would be affected by the higher noise levels is sufficiently low to justify noise limits tending towards the upper end of the range. Conversely, sites with relatively large power generating capacity should naturally justify limits towards the upper end of the range.

- 3.2.5 Given the large energy cumulative generating potential of the Proposed Development in combination with the existing operational wind farms considered in the area and the location of most surrounding properties which are located upwind of the proposed turbines under the south westerly conditions that prevail in the UK, the limit should tend towards the upper end of the 35 dB(A) to 40 dB(A) range. Furthermore, the consent for the Pen y Cymoedd Wind Farm stipulates 40 dB(A) as the relevant fixed component of the limit at surrounding dwellings for the day-time period. The appropriate choice of value is considered subsequently in Section 5.6 in this Report.
- 3.2.6 The night-time noise limit is derived from background noise data measured during the night-time periods (23:00 to 07:00) with no differentiation being made between weekdays and weekends. The ten minute $L_{A90,10min}$ noise levels measured over these night-time periods are again plotted against the concurrent wind speed data and a 'best-fit' correlation is established. As with the day-time limit, the night-time noise limit is also set as the greater of: a level 5 dB(A) above the best-fit background curve or a fixed level of 43 dB(A). This fixed lower night-time limit of 43 dB(A) was set in ETSU-R-97 on the basis of World Health Organization (WHO) guidance¹⁵ for the noise inside a bedroom and an assumed difference between outdoor and indoor noise levels with windows open. In the time since ETSU-R-97 was released, the WHO guidelines were revised to suggest a lower internal noise level, but conversely, a higher assumed difference between outdoor and indoor noise levels. Notwithstanding the WHO guideline revisions, the ETSU-R-97 limit remains consistent with current national planning policy guidance with respect to night-time noise levels. In addition, following revision of the night-time WHO criteria, ETSU-R-97 has been incorporated into planning guidance for Wales, England and Scotland and at no point during this process was it felt necessary to revise the guidance within ETSU-R-97 to reflect the change in the WHO guideline internal levels. The advice contained within ETSU-R-97 remains a valid reference on which to continue to base the fixed limit at night.
- 3.2.7 The exception to the setting of both the day-time and night-time lower fixed limits occurs in instances where a property occupier has a financial involvement in the wind farm development. Where this is the case then the lower fixed portion of the noise limit at that property may be increased to 45 dB(A) during both the day-time and the night-time periods alike.
- 3.2.8 The noise limits defined in ETSU-R-97 relate to the total noise occurring at a dwelling due to the combined noise of all operational wind turbines. The assessment will therefore need to consider the combined operational noise of the Proposed Development with other wind farms in the area to be satisfied that the combined cumulative noise levels are within the relevant ETSU-R-97 criteria. ETSU-R-97 also requires that the baseline levels on which the noise limits are based do not include a contribution from any existing turbine noise, to prevent unreasonable cumulative increases.
- 3.2.9 The IOA GPG also stresses the importance of considering noise levels allowed under the consent for operational or consented wind farms. The IOA GPG also suggests that cumulative noise effects need not be considered where differences between existing and proposed wind farm noise levels are 10 dB or more.
- 3.2.10 To undertake the assessment of operational noise in accordance with the foregoing methodology the following steps are required:

15 Environmental Health Criteria 12 – Noise. World Health Organisation, 1980.

- specify the number and locations of the wind turbines on all wind farms;
- identify the locations of the nearest, or most noise sensitive, neighbours;
- measure the background noise levels as a function of site wind speed at the nearest neighbours, or at least at a representative sample of the nearest neighbours;
- determine the day-time and night-time noise limits from the measured background noise levels at the nearest neighbours;
- specify the type and noise emission characteristics of the wind turbines;
- calculate the noise immission levels due to the operation of the wind turbines as a function of site wind speed at the nearest neighbours; and
- compare the calculated wind farm noise immission levels with the derived noise limits and assess in the light of planning requirements.

3.2.11 The foregoing steps, as applied to the Proposed Development, are set out subsequently in this assessment.

3.2.12 Note that in the above, and subsequently in this assessment, the term 'noise emission' relates to the sound power level actually radiated from each wind turbine, whereas the term 'noise immission' relates to the sound pressure level (the perceived noise) at any receptor location due to the combined operation of all wind turbines on the Proposed Development.

3.2.13 Noise from non-wind turbines sources associated with the Proposed Development, such as fixed plant associated with the substation and solar elements, are assessed using the BS 4142 standard. This standard provides a method for rating the potential impact of noise from fixed plant installations based on the background noise levels that prevail on a site. This is compared to a "rated level" of noise which is based on the L_{Aeq} level with the potential addition of penalties to account for some characteristics of the sound, considering the context of the situation: this requires consideration of factors such as the nature of the area and, particularly at night-time, the absolute level of the noise.

3.3 Construction Noise and Vibration Criteria

3.3.1 BS 5228-1 indicates a number of factors are likely to affect the acceptability of construction noise including site location, existing ambient noise levels, duration of site operations, hours of work, attitude of the site operator and noise characteristics of the work being undertaken.

3.3.2 BS 5228-1 informative Annex E provides example criteria that may be used to consider the magnitude of any construction noise impacts. The criteria do not represent mandatory limits but rather a set of example approaches intended to reflect the type of methods commonly applied to construction noise. The example methods are presented as a range of possible approaches (both facade and free field noise levels, hourly and day-time averaged noise levels) according to the ambient noise characteristics of the area in question, the type of development under consideration, and the expected hours of construction activity. In broad terms, the example criteria are based on a set of fixed limit values which, if exceeded, may result in a large impact unless ambient noise levels (i.e. regularly occurring levels without construction) are sufficiently high to provide a degree of masking of construction noise.

3.3.3 Based on the range of guidance values set out in BS 5228 Annex E, and other reference criteria provided by the World Health Organization (WHO) and Minerals Technical Advice Note 1: Aggregates (MTAN1), the following impact assessment scale has been derived. The values have been chosen in recognition of the relatively low ambient noise typically observed in rural environments. The presented criteria have been normalised to free-field day-time noise levels occurring over a time period, T, equal to the duration of a working day on-site. BS 5228-1 Annex E provides varied definitions for the range of day-time working hours which can be grouped for equal consideration. The values presented in Table 1 have been chosen to relate to day-time hours from 07:00 to 19:00 on weekdays, and 07:00 to 13:00 on Saturdays.

Table 1 - Construction Noise Impact Assessment

Impact	Noise Level dB L _{Aeq,T}		Description
	4 weeks or more	up to 4 weeks	
Major	> 75	> 85	Trigger level ¹⁶ for noise insulation works, or costs thereof, as set out in E.4 of BS 5228-1.
Moderate	> 65 ≤ 75	> 75 ≤ 85	Most stringent threshold values for potential significant effects given in Annex E of BS 5228-1 for example methods relevant to proposed development is exceeded.
Minor	> 55 ≤ 65	> 65 ≤ 75	Noise is likely to be audible, but unlikely to change behaviour. of BS 5228-1 thresholds not exceeded.
Negligible	≤ 55	≤ 65	At least 10 dB below the most stringent criteria provided in of BS 5228-1.

The values presented above relate to noise impacts that occur during working hours from 07:00 to 19:00 on weekdays, and 07:00 to 13:00 on Saturdays. Alternate criteria would apply to noise impacts outside of these hours. For noise impacts 13:00 to 19:00 on Saturdays and 07:00 to 19:00 on Sundays the above thresholds would reduce by 10 dB(A) in each category. For noise impacts 19:00 to 07:00 on any day the above thresholds would reduce by 20 dB(A) in each category.

3.3.4 When considering the impact of short-term changes in traffic, associated with the construction activities, on existing roads in the vicinity of the Project, reference can be made to the criteria set out in the Design Manual for Roads and Bridges (DMRB¹⁷). A classification of magnitudes of changes in the predicted traffic noise level calculated using the CRTN methodology is set out: for short-term changes such as those associated with construction activities, changes of less than 1 dB(A) are considered negligible, 1 to 3 dB(A) is minor, 3 to 5 dB(A) moderate and changes of more than 5 dB(A) constitute a major impact. This classification can be considered in addition to the criteria of Table 1.

3.3.5 Section B.2 of BS 5228-2 provides advice on human response to vibration in terms of Peak Particle Velocity (PPV). For PPV below 0.3 mm/s, this would be unlikely to be perceptible for residential receptors and impacts would be negligible. Levels between 0.3 and 1 mm/s would correspond to minor impacts, and levels between 1 mm/s and 10 mm/s would represent a moderate impact as they could cause complaint but could be tolerated with prior explanations. Levels of 10 mm/s and above would represent a major impact. BS 5228-2 also advises that any risk of building damage, even for sensitive buildings, would only occur at much stronger vibration levels (above 10 mm/s), therefore these criteria would also provide protection in this regard.

3.4 Operational Noise Criteria

3.4.1 The acceptable limits for wind turbine operational noise are clearly defined in the ETSU-R-97 document and these limits should not be breached. Consequently, the test applied to operational noise is whether or not the calculated wind farm noise immission levels at nearby noise sensitive properties lie below the noise limits derived in accordance with ETSU-R-97.

3.4.2 Depending on the levels of background noise the satisfaction of the ETSU-R-97 derived limits can lead to a situation whereby, at some locations under some wind conditions and for a certain proportion of the time, the wind farm noise may be audible. This could therefore represent an adverse impact for these properties. However, noise levels at the properties in the vicinity of the Proposed Development will still be within levels considered acceptable under the ETSU-R-97 assessment method. At other properties located further away, the noise levels would be lower still and may in some cases be inaudible (or only audible for very limited periods), which would represent a negligible impact.

¹⁶ The triggers for noise insulation described in section E.4 of BS 5228-1 apply when works occur at certain noise levels for a period of 10 or more days of working in any 15 consecutive days or for a total number of days exceeding 40 in any 6 consecutive months.

¹⁷ The Highways Agency, Transport Scotland, Transport Wales and The Department for Regional Development (Northern Ireland) (2020). 'Design Manual for Roads and Bridges, LA 111 Noise and vibration', revision 2.

3.5 Consultation

Scoping stage and initial consultation

3.5.1 The scoping report for the Proposed Development¹⁸ outlined the methodology to be used for the present assessment, and in particular proposed to undertake the assessment of operational noise from the Proposed Development on the basis of the data previously measured at neighbouring properties as part of the assessment for the Pen-y-Cymoedd Wind Farm¹⁹.

3.5.2 The scoping response²⁰ from Planning and Environment Decision Wales (PEDW) disagreed with the above approach to reuse the Pen-y-Cymoedd (PYC) survey data, on the basis (ID.17) that:

The baseline noise data presented in the Pen – y – Cymoedd Wind Farm ES are not up to date as the ES was prepared a few years ago. Additionally, the proposed development is closer to residential developments at Tonmawr than Pen y Cymoedd thus the two developments do not share the same sensitive receptors. PEDW considers that a new baseline survey should be completed to inform the ES. Locations should be discussed with NPTCBC [Neath Port Talbot County Borough Council].

3.5.3 Although the noise surveys for the PYC Wind Farm were undertaken in 2008, they were reviewed and determined to have been undertaken in line with current good practice as set out in the 2013 Institute of Acoustics Good Practice Guide. Furthermore, the noise environment in the area is considered unlikely to have materially changed in the meantime, aside from the presence of operational wind turbine noise from the PYC Wind Farm (which has since been constructed); however, as noted above at 3.2.8, the ETSU-R-97 guidance requires any background noise survey to exclude the influence of existing turbines.

3.5.4 Furthermore, the surveys for PYC Wind Farm comprised properties which were considered sufficiently representative of the closest locations to the Proposed Development, including several survey locations in Tonmawr. This was confirmed on a site visit of the area in August 2022. It was also proposed to apply a correction to account for the difference in hub height between the turbines for the Proposed Development and those of PYC (see 4.3.3).

3.5.5 This was set out in a detailed discussion with Dick Bowdler, an independent consultant appointed by Neath Port Talbot County Borough Council (NPTCBC) to provide a response to the above scoping request. His response²¹ noted that he had no objection to the use of the PYC data as suggested, provided that care is taken when using data affected by noise from water courses: this should only be used to represent other properties similarly affected by this source. In particular: for “*properties at Tonmawr north of Glenview, background noise should be that made at Uwch y Glyn Farm*”.

3.5.6 Mr Bowdler also added that:

- The assessment of cumulative noise should be in accordance with the guidance in ETSU-R-97 and the IOA GPG (as suggested, as well as further guidance set out in an IOA Bulletin article²². In particular, the proposed use of the “controlling property”²³ approach (see Annex B) is considered acceptable. The potential impact of the Ffynnon Oer Wind Farm should be considered.

18 Mynydd Fforch Dwm Wind farm, EIA scoping report, February 2022.

19 Pen-y-Cymoedd Wind Farm Environmental Statement, Section 11: noise assessment and shadow flicker (and technical appendices), 2009.

20 Planning and Environment Decision Wales (PEDW), DNS: EIA Scoping Direction, 3255801: Mynydd Fforch Dwm, 24 June 2022.

21 Dick Bowdler, Mynydd Fforch Dwm Wind Farm, Scoping Response on Noise, 29th August 2022.

22 Bowdler et al, Wind farms cumulative impact assessments, Jan/Feb 2016 Acoustics Bulletin, Institute of Acoustics.

23 The potential noise emissions from a consented/operational wind farm are in many cases effectively restricted by complying with their consent noise limit at particular properties located closest to that scheme.

- According to the Institute of Environmental Management and Assessment (IEMA), although “*ETSU-R-97 is endorsed by government that does not relieve the assessor of the need to describe the impact of the development. As with other disciplines there should be a clear explanation of the impact. It is not sufficient (or accurate) to say, for example, that where ETSU-R-97 limits are met there is no impact.*”

This is addressed at 6.1.7 with a description of the audible noise from the wind turbines representing an adverse impact, albeit not a significant one.

- “*The normal threshold levels for construction should not be considered as acceptable on a site such as this where there are large separation distances to properties. Construction noise levels should generally be kept significantly lower than those. Detailed calculations of construction noise levels on a day by day or week by week basis are not required but a clear method statement as to how the construction is to be carried out and where the main noise generating activity is to be. The effect of this on local properties should be clearly stated in qualitative terms and a description of the mitigating measures to be taken included. In particular any activity likely to take place outside 0700 to 1900 on a normal weekday should be identified.*”

This is addressed in section 5.1 below.

- 3.5.7 In summary, further detailed consultation with NPTCBC’s appointed consultant has addressed the initial concerns raised by PEDW. The present assessment has taken into account the comments raised as part of this consultation. The use of the agreed monitoring data at different locations is set out below in further detail in section 4.2.

Pre-Application Consultation

- 3.5.8 A draft version of this environmental noise assessment was submitted as part of the Pre-Application Consultation (PAC) process for a Development of National Significance (DNS) and was reviewed by Mr Bowdler on behalf of NPTCBC. The outcome of this review was set out in a report²⁴ dated 31 March 2023. The review did not highlight any significant risks or objections and reiterated that the approach taken in relation to the baseline noise levels from the PYC application was suitable. The review also agreed a lower ETSU-R-97 noise limit of 40 dB (applied consistently with the PYC consent as set out in section 4.3 below) was appropriate based on the character of the noise environment. This 40 dB based noise limit would however apply to control total cumulative wind turbine noise, as required by ETSU-R-97.

- 3.5.9 The review report nonetheless raised several points which required consideration as part of the assessment, which are summarised as follows:

- **Additional properties:** it was recommended that additional properties are considered in the assessment, including a location indicated as Blaen Cwmbach on Ordnance Survey (OS) mapping, and properties in Duffryn including Hendre Owen Farm. The potential for cumulative effects from wind farm developments at Foel Trawsant and Y Bryn should also be considered.
- **Significance of impact:** Mr Bowdler criticises the assessment of operational noise from the proposed wind turbines against the criteria of ETSU-R-97 as a “pass or fail” assessment with no more detailed description of the potential impact “significance”, although some of the advice cited relates to policy in England rather than Wales. The potential adverse effects of noise are clearly described in the assessment (accounting for Mr Bowdler’s comments) but a more detailed quantification of impact scale is not considered relevant, necessary or practical in this context.

²⁴ Dick Bowdler, Mynydd Fforch Dwm Wind Farm, Review of the noise section of the application, 31 March 2023.

- **Substation and solar:** additional detailed estimates were requested, and although the location of noise sources in the solar area is not determined at this stage, an analysis is presented on a worst-case basis in Section 5.9.
- **Noise limits and conditions:** whilst ETSU-R-97 considers different noise limits for both day-time and night-time, the review recommended controlling noise from the scheme based on the day-time noise limits derived which are the most restrictive. The report also included a planning condition wording which included a penalty for control of amplitude modulation (see section 5.8).
- **Construction noise:** the review noted that construction noise and vibration impacts could be controlled through a Construction Environment Management Plan (secured through planning conditions for the scheme) which would take into account the mitigation measures considered in section 5.1.

4. Baseline

4.1 General Description

- 4.1.1 The Development is located north and north-east of the settlement at Tonmawr and neighbouring properties. Isolated properties can also be found east of Tonmawr including Fforch-dwm Farm on Mynydd Fforch-dwm, which is involved with the Proposed Development. The area north and north-east of the Site has a comparably very low population density with the closest dwellings located more than 3 km away.
- 4.1.2 The noise environment in the surrounding area generally comprises a mix of ‘natural’ and man-made sources. The former includes wind-disturbed vegetation, birds, farm animals and as well as, to varying extent, noise from water courses such as the Pelenna River in particular. Other sources of noise include intermittent local road and agricultural vehicle movements, as well as noise from operational wind turbines at some of the properties (in some wind conditions).

4.2 Details of the Baseline Background Noise Data

- 4.2.1 A total of 4 out of the 30 noise monitoring locations measured as part of the PYC assessment were referenced, as agreed with the Local Authority’s consultant, as being representative of the background noise environment for the nearest residences to the proposed wind farm site. The 4 locations are shown on the plan in Annex B and listed in Table 2.

Table 2 - Background Noise Monitoring Locations referenced (approximate Easting / Northing)

No.	Property	PYC survey property reference	Easting	Northing
1	Fforch-dwm Farm	PYC23	282095	197226
2	Gyfylchi Farm	PYC24	281025	195624
3	Glenview, Railway Terrace	PYC25	280727	196211
4	Uwch-y-Glyn	PYC26	280077	196765

- 4.2.2 The assessment has considered operational noise from the Proposed Development at the monitoring locations noted above, as well as other residential properties: these assessment locations are listed in Table 3. The list of receptor locations is not intended to be exhaustive but sufficient to be representative of noise levels typical of those receptors closest to the Proposed Development.
- 4.2.3 One location named Blaen Cwmbach on Ordnance Survey (OS) mapping appears derelict and is not registered as residential in planning records and was therefore not considered further in the assessment.

- 4.2.4 Additional properties located further away (not listed in Table 3) are also considered following consultation in relation to other cumulative wind turbine developments in the area: see Section 5.7. For example, the property of Troed-y-rhiw located east of the Site and south of the Ffynnon Oer Wind Farm (considered in Annex B) but the contribution of the Proposed Development at that property is negligible (see cumulative analysis below for further detail). Properties in Duffryn and those to the north of Blaen Cwmbach are also considered.
- 4.2.5 The results obtained at the four PYC survey positions of Table 2 have been used to represent the background environment expected to occur at other nearby assessment locations. The use of the data in this way is justified by the influence of the different sources of background noise levels observed in the area, accounting for the consultation undertaken and described above (see section 3.5). The choice of survey location was applied in a conservative way: for example, on Railway Terrace (east of Tonmawr), an influence of water noise from the Pelenna river was observed to be audible. However, for this property, the survey results obtained at Uwch-y-Glyn, which did not appear to be strongly influenced by water noise, were used instead of the data measured at Glenview. The results from the latter property were applied at Pelenna House but this property is located very close to the river and experiencing stronger levels of water noise. The results at Uwch-y-Glyn were used for most properties in Tonmawr.
- 4.2.6 This approach is consistent with the guidance provided by ETSU-R-97 and current good practice as set out in the IOA GPG. Locations where such representations have been made, and the source of the representations, are presented in Table 3.

Table 3 - Assessment properties in the vicinity of the proposed development

Property	Easting	Northing	Approximate Distance to Closest Turbine (m)	Closest Turbine (ID)	Survey Location
Fforch-dwm Farm*	282101	197216	520	T5	Fforch-dwm Farm
Pelenna House	281654	196956	920	T1	Glenview, Railway Terrace
Glenview	280732	196236	1370	T2	Glenview, Railway Terrace
Tonmawr Farm	280779	196284	1330	T2	Uwch-y-Glyn
Railway Terrace	280615	196289	1310	T2	Uwch-y-Glyn
Brynhyfryd House	280348	196395	1240	T2	Uwch-y-Glyn
Blaenavon Terrace	280092	196520	1210	T2	Uwch-y-Glyn
Uwch-y-Glyn	280077	196765	1010	T2	Uwch-y-Glyn
Blaenafon Farm	280135	196771	970	T2	Uwch-y-Glyn
Jonhs Terrace (end)	280039	196802	1000	T2	Uwch-y-Glyn
Tynton	280402	195872	1750	T2	Gyfylchi Farm
Gyfylchi	281049	195668	1980	T2	Gyfylchi Farm
* Financially involved with the proposed development					

4.3 Measured Background Noise Levels

- 4.3.1 The ETSU-R-97 assessment method requires noise data to be related to wind speed data at a standardised height of ten metres, with wind speeds either directly measured at a height of ten metres or by calculation from measurement at other heights, the appropriate choice being determined by practitioner judgement and the available data sources. Since the publication of ETSU-R-97, the change in wind speed with increasing height above ground level has been identified as a potential source of variability when carrying out wind farm noise assessments. The effect of site specific wind shear can be appropriately addressed by implementing the ETSU-R-97 option of deriving ten metre height reference data from measurements made at taller heights.
- 4.3.2 This method was used in the noise assessment for the PYC Wind Farm to account for the potential effect of site-specific wind shear, as noted above. This method is consistent with the preferred method described in the IOA GPG. Wind speeds were measured on a temporary meteorological mast located just east of Mynydd Fforch-Dwm (approximate easting and northing 283817 / 197500). Values of wind speed at a standardised height of ten metres were calculated from those measured on the tall mast ("standardised wind speed") based on a hub height of 100 m, in accordance with the preferred method in the IOA GPG guidance. The PYC assessment also explains how the measured noise data was analysed, with periods affected by rainfall and atypical noise events excluded, also in accordance with IOA GPG guidelines.
- 4.3.3 The hub heights of the turbines of the Proposed Development are of up to 145 m (see below), which is higher than the height assumed in the PYC assessment. Following guidance in the IOA GPG Supplementary Guidance Note 4 ("Wind Shear")²⁵, it was estimated that the likely effects of the height difference in question would be of less than 1 m/s, even accounting for relatively high shear periods for the type of terrain present in the area. Therefore, a correction of 1 m/s was applied by increasing the wind speed references, which had the effect of shifting the background curves "to the right", i.e. the value obtained at 7 m/s was applied at 8 m/s etc. This represents a relative decrease in the associated noise limits and therefore a precautionary approach to the assessment, which will also account for potential differences in wind conditions between the sites.
- 4.3.4 Figures C1 to C8 of Annex C show the results of the background noise measurements at each of the four locations of Table 2. Two plots are shown for each location, one for quiet day-time periods and the other for night-time periods, both derived in accordance with ETSU-R-97. The charts show both the original derived trendline of typical measured background levels and the revised curve adjusted for wind shear effects as described above.
- 4.3.5 These derived background noise levels were then used to derive the noise limits required by ETSU-R-97 that apply during the day-time and night-time periods up to 12 m/s. The corresponding ETSU-R-97 noise limits are summarised in Table 4 and Table 5. The noise limits have been set either at the prevailing measured background level plus 5 dB, or at the relevant fixed lower limit, whichever is the greater. The derivation of the relevant fixed lower limit value used for day-time periods (40 dB(A)) is described in section 5.6. For Fforch-dwm Farm, the lower absolute limit becomes 45 dB(A).
- 4.3.6 As noted in section 3.5, the day-time limits of Table 4 are more stringent and therefore represent the main basis of the analysis.

²⁵ A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise - Supplementary Guidance Note 4: Wind Shear, M. Cand, R. Davis, C. Jordan, M. Hayes, R. Perkins, Institute of Acoustics, July 2014.

Table 4 - Day time $L_{A90,T}$ noise limits derived from the baseline noise survey according to ETSU-R-97

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Fforch-dwm Farm	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.7	48.9
Pelenna House	40.0	40.0	40.7	42.0	43.2	44.2	45.0	45.7	46.3	46.6	46.9	46.9
Glenview	40.0	40.0	40.7	42.0	43.2	44.2	45.0	45.7	46.3	46.6	46.9	46.9
Tonmawr Farm	40.0	40.0	40.0	40.0	40.1	40.5	41.1	41.9	42.8	43.8	45.0	46.4
Railway Terrace	40.0	40.0	40.0	40.0	40.1	40.5	41.1	41.9	42.8	43.8	45.0	46.4
Brynhyfryd House	40.0	40.0	40.0	40.0	40.1	40.5	41.1	41.9	42.8	43.8	45.0	46.4
Blaenavon Terrace	40.0	40.0	40.0	40.0	40.1	40.5	41.1	41.9	42.8	43.8	45.0	46.4
Uwch-y-Glyn	40.0	40.0	40.0	40.0	40.1	40.5	41.1	41.9	42.8	43.8	45.0	46.4
Blaenafon Farm	40.0	40.0	40.0	40.0	40.1	40.5	41.1	41.9	42.8	43.8	45.0	46.4
Jonhs Terrace (end)	40.0	40.0	40.0	40.0	40.1	40.5	41.1	41.9	42.8	43.8	45.0	46.4
Tynton	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.6	43.3	46.3	49.7
Gyfylchi	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.6	43.3	46.3	49.7

Table 5 - Night time $L_{A90,T}$ noise limits derived from the baseline noise survey according to ETSU-R-97

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Fforch-dwm Farm	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.3
Pelenna House	43.0	43.0	43.0	43.2	43.7	44.1	44.5	44.8	45.0	45.1	45.1	45.1
Glenview	43.0	43.0	43.0	43.2	43.7	44.1	44.5	44.8	45.0	45.1	45.1	45.1
Tonmawr Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1	43.1	43.1
Railway Terrace	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1	43.1	43.1
Brynhyfryd House	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1	43.1	43.1
Blaenavon Terrace	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1	43.1	43.1
Uwch-y-Glyn	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1	43.1	43.1
Blaenafon Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1	43.1	43.1
Jonhs Terrace (end)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.1	43.1	43.1
Tynton	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Gyfylchi	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

5. Noise Impact Assessment

5.1 Predicted Construction Noise Levels

- 5.1.1 The level of construction noise that occurs at the surrounding properties will be highly dependent on a number of factors such as the final site programme, equipment types used for each process, and the operating conditions that prevail during construction. It is not practically feasible to specify each and every element of the factors that may affect noise levels, therefore it is necessary to make reasonable allowance for the level of noise emissions that may be associated with key phases of the construction.
- 5.1.2 In order to determine representative emission levels for this study, reference has been made to the scheduled sound power data provided by BS 5228. Based on experience of the types and number of equipment usually associated with the key phases of constructing a wind farm, the scheduled sound power data has been used to deduce the upper sound emission level over the course of a working day. In determining the rating applicable to the working day, it has generally been assumed that the plant will operate for between 75% and 100% of the working day. In many instances, the plant would actually

be expected to operate for a reduced percentage, thus resulting in noise levels lower than predicted in this assessment.

- 5.1.3 To relate the sound power emissions to predicted noise levels at surrounding properties, the prediction methodology outlined in BS 5228 has been adopted. The prediction method accounts for factors including screening and soft ground attenuation. The size of the site and resulting separation distances to surrounding properties allows the calculations to be reliably based on positioning all the equipment at a single point within a particular working area (for example, in the case of turbine erection, it is reasonable to assume all associated construction plant is positioned at the base of the turbine under consideration). In applying the BS 5228 methodology, it has been conservatively assumed that there are no screening effects, and that the ground cover is characterised as 50% hard / 50% soft.
- 5.1.4 Table 6 lists the key construction activities, the associated types of plant normally involved, the expected worst-case sound power level over a working day for each activity, the property which would be closest to the activity for a portion of construction, and the predicted noise level. It must be emphasised that these predictions only relate the noise level occurring during the time when the activity is closest to the referenced property. In many cases such as access track construction and turbine erection, the separating distances will be considerably greater for the majority of the construction period and the predictions are therefore the worst-case periods of the construction phase.

Table 6 - Predicted construction noise levels

Task Name	Plant/Equipment	Upper Collective Sound Emission Over Working Day L _{WA,T} dB(A)	Nearest Receiver	Minimum Distance to Nearest Receiver	Predicted Upper Day-Time L _{Aeq}
Upgrade Access Track	excavator / dump trucks / tippers / dozers / vibrating rollers	120	Pelenna House	80	73
Construct temporary site compounds	excavator / dump truck / tippers / rollers/ delivery trucks	120	Blaenafon Farm	280	61
Construct site tracks (worst-case)	excavators / dump trucks / tippers / dozers / vibrating rollers	120	Brynhyfryd House	25	84 (see below)
Construct site tracks (Other properties in Tonmawr)	excavators / dump trucks / tippers / dozers / vibrating rollers	120	Next nearest houses in Tonmawr	65	75
Construct Sub-Station	excavator / concrete truck / delivery truck	110	Blaenafon Farm	280	51
Construct crane hardstandings	excavators / dump trucks	120	Pelenna House	900	49
Construct turbine foundations	Piling Rigs / excavators / tippers / concrete trucks / mobile cranes / water pumps / pneumatic hammers / compressors / vibratory pokers	120	Pelenna House	920	49

Task Name	Plant/Equipment	Upper Collective Sound Emission Over Working Day L_{WAT} dB(A)	Nearest Receiver	Minimum Distance to Nearest Receiver	Predicted Upper Day-Time L_{Aeq}
Excavate and lay site cables	excavators / dump trucks / tractors & cable drum trailers / wacker plates	110	Brynhyfryd House	25	74
Erect turbines	cranes / turbine delivery vehicles / artics for crane movement / generators / torque guns	120	Pelenna House	920	49
Reinstate crane bases	excavator / dump truck	115	Pelenna House	900	44
Reinstate road verges	excavator / dump truck	115	Pelenna House	80	68
Lay cable to sub-stations	JCB / saws / hydraulic breaker / dump truck/ tipper / wacker plate / tandem roller / tractor & cable drum trailer / delivery truck	115	Railway terrace	10	87 (very short period, see below)
Concrete Batching	Batching Plant	110	Blaenafon Farm	280	51
Solar foundations piling	Tubular steel piling - hydraulic jacking / Mobile Cranes / Wheeled backhoe loader	117	Blaenafon Farm	430	54

- 5.1.5 Comparing the above predicted noise levels to the range of background noise levels measured around the Proposed Development suggests that the noisier construction activities would be audible at various times throughout the construction phase. However, comparing the levels to the impact criteria presented previously indicates that the majority of construction activities will have impacts of negligible to minor magnitude.
- 5.1.6 However, activities associated with road upgrade, cable laying and construction of new site access track will occur at shorter distances to some properties. Most of the track upgrade work is likely to be relatively limited and completed in a very short time, in particular for properties along Railway Terrace, and the predicted noise levels are likely to represent those for a very short term period when activity is closest to these receptors. Noise levels will quickly diminish as this construction activity progresses, moving the activity further from the properties, with the impact similar in nature to road maintenance work. The short-term nature of this activity consequently categorises the impact to be of **minor** magnitude at most.
- 5.1.7 The construction of the new site access to the turbines on Mynydd Blaenafon will however involve more earthwork and therefore a longer works duration, occurring in relatively close proximity to some properties in Tonmawr, in particular Brynhyfryd House²⁶. Specifically, a portion of approximately 150 m of the new access track would be constructed within 60 m of the properties of Brynhyfryd House. Although the works for this portion of track are likely to last less than one month, with noise levels between 75 to 85dB L_{Aeq} , this would represent a moderate impact according to the criteria in Table 1.

²⁶ Note that this location includes two semi-detached dwellings.

For other properties in Tonmawr, the increased separation distance will mean that the associated noise levels would correspond to a minor impact.

- 5.1.8 The potential impact of the access track construction in proximity of Brynhyfryd House should be minimised where possible. It is considered feasible to substantially reduce noise levels (by 10 dB or more) from these activities using temporary solid screening, close to the property boundary, of a height sufficient to screen the track construction activities. The final design and specification of such screening should be determined as part of the detailed design of the access track, following ground investigations. The above predictions are on the basis of worst-case assumptions and it may be that reduced levels of activity or reduced construction hours could correspond to reduced noise levels, although this may extend the duration of the works. If noise levels could be reduced (using these measures) not to exceed 75 dB L_{Aeq} over the working day through screening or other measures, with brief exceptions, the impact at the property from these activities at Brynhyfryd House would reduce to a minor magnitude. Noise monitoring during this phase of the construction would assist in managing these impacts. This could be implemented within the CEMP. If impact at Brynhyfryd House is predicted to likely remain above 75 dB L_{Aeq} , for a period of 10 or more days of working in any 15 consecutive days or for a total number of days exceeding 40 in any 6 consecutive months, noise insulation (or the costs thereof) should be proposed for these residents.
- 5.1.9 In terms of vibration, the new access track works may involve vibratory ground compaction. Using guidance in BS 5228-2, based on worst-case assumptions (0.8 mm drum vibration amplitude and a 1.5 m drum width), vibration levels at 25 m distance could be close to 1 mm/s at steady state but marginally above 1 mm/s at start-up/run-down. It is difficult to estimate what vibration could be produced by the groundworks associated with this activity as this would depend on the ground/rock conditions but there is a potential for levels between 1 and 10 mm/s to be produced at times. Based on BS 5228-2 guidance, these levels would cause complaint but could be tolerated with prior explanations. Therefore, engagement with residents is recommended to warn them of the proposed works that some vibration may be perceptible at times but building damage is unlikely. Furthermore, monitoring of the vibration levels during the access track construction is recommended to check vibration levels during this phase of the works and that they do not approach or exceed a PPV level of 10 mm/s.
- 5.1.10 In addition to on-site activities, construction traffic passing to and from the site will also represent a potential source of noise to surrounding properties. The assessment in Chapter 13 and Appendix 13.1 of the EIA report for the proposed Development (Transport and Access) has predicted the volume of traffic likely to be generated during the construction of the proposed Development. This concluded that the maximum traffic during the construction programme would occur in month 5 with 138 HGV trips per day, or an average maximum of less than 12 heavy vehicle movements each hour, based on a 12-hour day. Table 5 of Appendix 13.1 was used to ascertain the baseline traffic flow for 2025 and Table 13 of Appendix 13.1 for the projected traffic flows during peak construction activities. These projected changes in traffic flow are summarised in Table 7.
- 5.1.11 The first receptors considered are properties on Fforch-dwm Road which currently experience relatively low levels of traffic. The predicted traffic flow value with construction is well below the minimum flow volume of 1000 vehicles per day that is required by the CRTN methodology to enable reliable predictions, however the prediction methodology in BS 5288 can be referenced in this case. Large vehicles can generate noise levels in the order of 108 dB (sound power level) when in motion. However, these types of plant usually pass a receiver location quite quickly. When stationary, the same vehicles will be operating in idle which considerably lowers the noise output to the environment. Based on and accounting for 4 construction vehicles per hour (based on 50 HGVs per day using that road based on Appendix 13.1), moving at an estimated 20 miles per hour²⁷, the predicted noise level at the

²⁷ A speed of 20 mph is estimated based on our experience of this type of activity and considered reasonably representative.

dwelling on Fforch-dwm Road is of 59 dB L_{Aeq} , which represents a minor impact based on the criteria of Table 1.

- 5.1.12 The noise from traffic using the new site access track north of Brynhyfryd House can also be assessed in the same way. Even assuming the full 138 HGVs per day (on Ton-Mawr Road) was using this access track to Mynydd Blaenafon, this would still equate to a level of 52 dB L_{Aeq} , dB at the property, representing a negligible impact.
- 5.1.13 For the traffic on other local surrounding roads, the methodology set out in CRTN has been used to determine the associated maximum total change in the average day time traffic noise level at any given location, due to construction of the Development: see Table 8. A maximum increase of 1.5 dB in the day-time average noise level is predicted on Ton-Mawr Road. Based on the criteria set out in the DMRB, this predicted short-term change in traffic noise levels corresponds to a minor impact. For the other roads considered, the predicted increase was of less than 0.5 dB which corresponds to a negligible impact.

Table 7 - Projected traffic flows

Road	Without Development		With Development	
	Annual Average Daily Traffic Flow	% Heavy Goods Vehicles	Annual Average Daily Traffic Flow	% Heavy Goods Vehicles
Fforch-dwm Road	129	17.8%	187	39.0%
Ton-Mawr Road	1730	13.4%	1892	19.5%
B4287, east of Cimla Community Centre	8812	1.3%	8972	2.8%
A465, west of Neath Abbey Interchange	45640	4.7%	45780	4.9%
A4107, approximately 1.15 km south of junction with B4287 (DfT 78497)	4227	1.6%	4229	1.6%
A4107, north of Gwar-Y Caeau	6178	1.8%	6180	1.8%

Table 8 - CRTN predicted increase in day-time average traffic noise levels ($L_{A10,18hour}$)

Road	Maximum Change in Traffic Noise Level, dB(A)
Ton-Mawr Road	1.5
B4287, east of Cimla Community Centre	0.4
A465, west of Neath Abbey Interchange	0.1
A4107, approximately 1.15 km south of junction with B4287 (DfT 78497)	0.0
A4107, north of Gwar-Y Caeau	0.0

- 5.1.14 In conclusion, noise from construction activities has been assessed and is predicted to result in a temporary negligible to minor impact in most cases, with a moderate impact on Brynhyfryd House potentially mitigated through management and screening measures.

- 5.1.15 This conclusion is based on construction activities generally being limited to the following working hours: from 07:00 to 19:00 on weekdays, and 07:00 to 13:00 on Saturdays. However, activities that are unlikely to give rise to noise audible at the site boundary will continue outside of the stated hours. Furthermore, turbine deliveries may take place outside these times with the prior consent of the relevant authorities. In addition, good practice measures recommended in BS 5228-1 should be used to minimise construction noise levels.

5.2 Decommissioning Noise

- 5.2.1 Decommissioning is likely to result in less noise than during construction of the Proposed Development. The works required to build the site access to Mynydd Blaenafon will also not be required. The construction phase has been considered to have minor noise impacts at most (following mitigation), therefore decommissioning will, in the worst case, also have minor noise impacts.

5.3 Operational Wind Turbine Emissions Data

- 5.3.1 The exact model of turbine to be used at the site will be the result of a future tendering process and therefore a representative turbine model has been assumed for this noise assessment. This operational noise assessment is based upon the noise specification of the Vestas V150 6MW wind turbine. Six turbines have been modelled using the layout as indicated on the map and coordinates within Annex B. The noise emission levels for this turbine model are considered robust as they result in noise emission levels which are higher or similar to other turbines of similar dimensions (rotor diameters of up to 155 metres).
- 5.3.2 The candidate turbine is a variable speed, pitch regulated machine with a rotor diameter of 150 metres and hub heights varying between 105 and 125 metres. Due to its variable speed operation the sound power output of the V150 turbine varies considerably with wind speed, being quieter at the lower wind speeds when the blades are rotating more slowly. Annex B details noise emission data for the V150 6MW turbine, which was derived based on information provided by Vestas, with the addition of an allowance for uncertainty in line with the guidance of the IOA GPG.
- 5.3.3 Assessment of the cumulative noise from operating the Proposed Development with other wind farms requires source information for the turbine types for each wind farm, similar to that for the Proposed Development: these are also detailed in Annex B.
- 5.3.4 For the Pen-y-Cymoedd (PYC) Wind Farm, the noise emissions are based on the Siemens SWT-3.0-108 and SWT-3.0-113 turbine models installed at the site. In addition, a further margin of +2.6 dB was added such that the PYC consent limit is just achieved at the closest relevant property, Fforch-dwm Farm. It is therefore unlikely that noise emissions from PYC could be higher without resulting in potential excess of their individual consent noise limits, and the modelling assumptions for the cumulative analysis are therefore in line with the IOA GPG guidance.
- 5.3.5 The Ffynnon Oer Wind Farm was also modelled based on the installed turbine model, as raised during the consultation referenced above. In the absence of clear noise requirements for that site and given that the resulting contribution at the properties nearest to the Proposed Development was generally negligible²⁸, adding further additional margins to the assumed noise emission levels was not considered necessary.
- 5.3.6 Similarly, the proposed Melin Court Wind Farm, located 4 km north-east from the properties of Table 3, is likely to represent a negligible contribution of less than 25 dB L_{A90} at relevant properties and was therefore not considered further.

28 The IOA GPG suggests that cumulative noise effects need not be considered where differences between existing and proposed wind farm noise levels are 10 dB or more.

5.4 Choice of Wind Farm Operational Noise Propagation Model

- 5.4.1 The ISO 9613-2 model²⁹ has been used to calculate the noise immission levels at the selected nearest residential neighbours as advised in the IOA GPG. The model accounts for the attenuation due to geometric spreading, atmospheric absorption, and barrier and ground effects. All attenuation calculations have been made on an octave band basis and therefore account for the sound frequency characteristics of the turbines.
- 5.4.2 For the purposes of the present assessment, all noise level predictions have been undertaken using a receiver height of four metres above local ground level, mixed ground ($G=0.5$) and an air absorption based on a temperature of 10°C and 70% relative humidity. A receiver height of four metres will be typical of first floor windows and result in slightly higher predicted noise levels than if a 1.2 to 1.5 metre receiver height were chosen in the ISO 9613 algorithm. The attenuation due to terrain screening accounted for in the calculations has been limited to a maximum of 2 dB(A). In situations of propagation above concave ground, a correction of +3dB was added. These propagation factors are shown in Annex B.
- 5.4.3 This method is consistent with the recommendations of the above-referenced Institute of Acoustics Good Practice Guide which provides recommendations on the appropriate approach when predicting wind turbine noise levels. The IOA GPG also allows for directional effects to be taken into account within the noise modelling: under upwind propagation conditions between a given receiver and the wind farm the noise immission level at that receiver can be as much as 10 dB(A) to 15 dB(A) lower than the level predicted using the ISO 9613-2 model. However, predictions have been made assuming downwind propagation from every turbine to every receptor at the same time as a worst-case.

5.5 Predicted Wind Farm Operational Noise Immission Levels

- 5.5.1 Table 9 shows predicted noise immission levels at each of the selected assessment locations for each wind speed over the relevant range of wind speeds for the Proposed Development alone. All wind farm noise immission levels in this report are presented in terms of the $L_{A90,T}$ noise indicator in accordance with the recommendations of the ETSU-R-97 report, obtained by subtracting 2 dB(A) from the calculated $L_{Aeq,T}$ noise levels based on the turbine sound power levels presented in Annex B.

29 ISO 9613-2:1996 'Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation', International Standards Organisation, 1996.

Table 9 - Predicted L_{A90} wind farm noise immission levels at each of the noise assessment locations as a function of standardised wind speed for the Proposed Development alone.

Property	Standardised 10 m Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Fforch-dwm Farm	30.7	34.3	38.7	42.0	42.5	42.6	42.6	42.6	42.6	42.6
Pelenna House	26.5	30.0	34.4	37.7	38.4	38.5	38.5	38.5	38.5	38.5
Glenview	19.3	22.7	27.1	30.5	31.2	31.3	31.3	31.3	31.3	31.3
Tonmawr Farm	19.7	23.1	27.5	30.9	31.6	31.7	31.7	31.7	31.7	31.7
Railway Terrace	19.4	22.9	27.2	30.6	31.3	31.4	31.4	31.4	31.4	31.4
Brynhyfryd House	19.4	22.8	27.2	30.6	31.3	31.4	31.4	31.4	31.4	31.4
Blaenavon Terrace	20.4	23.8	28.1	31.6	32.3	32.4	32.4	32.4	32.4	32.4
Uwch-y-Glyn	22.4	25.8	30.1	33.6	34.3	34.4	34.4	34.4	34.4	34.4
Blaenafon Farm	22.8	26.2	30.5	34.0	34.7	34.8	34.8	34.8	34.8	34.8
Jonhs Terrace (end)	22.4	25.8	30.1	33.6	34.4	34.5	34.5	34.5	34.5	34.5
Tynton	19.8	23.3	27.7	31.0	31.7	31.8	31.8	31.8	31.8	31.8
Gyfylchi	20.1	23.6	27.9	31.3	32.0	32.1	32.1	32.1	32.1	32.1

Table 10 - Predicted L_{A90} wind farm noise immission levels at each of the noise assessment locations as a function of standardised wind speed for the Pen y Cymoedd Wind Farm.

Property	Standardised 10 m Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Fforch-dwm Farm	25.1	29.6	34.2	38.6	40.0	40.1	40.1	40.1	40.1	40.1
Pelenna House	21.8	26.2	30.9	35.3	36.7	36.8	36.8	36.8	36.8	36.8
Glenview	16.9	21.4	26.0	30.4	31.9	32.0	32.0	32.0	32.0	32.0
Tonmawr Farm	17.1	21.6	26.2	30.6	32.1	32.2	32.2	32.2	32.2	32.2
Railway Terrace	16.2	20.6	25.2	29.7	31.2	31.2	31.2	31.2	31.2	31.2
Brynhyfryd House	15.6	20.1	24.7	29.1	30.7	30.7	30.7	30.7	30.7	30.7
Blaenavon Terrace	15.2	19.6	24.3	28.7	30.2	30.3	30.3	30.3	30.3	30.3
Uwch-y-Glyn	15.4	19.9	24.5	28.9	30.5	30.5	30.5	30.5	30.5	30.5
Blaenafon Farm	15.6	20.0	24.6	29.1	30.6	30.7	30.7	30.7	30.7	30.7
Jonhs Terrace (end)	15.4	19.8	24.4	28.9	30.4	30.5	30.5	30.5	30.5	30.5
Tynton	17.6	22.0	26.7	31.1	32.5	32.6	32.6	32.6	32.6	32.6
Gyfylchi	17.2	21.6	26.2	30.7	32.2	32.3	32.3	32.3	32.3	32.3

Table 11 - Predicted L_{A90} wind farm noise immission levels at each of the noise assessment locations as a function of standardised wind speed for the Ffynnon Oer Wind Farm.

Property	Standardised 10 m Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Fforch-dwm Farm	10.6	14.6	18.5	22.1	25.3	27.2	28.3	28.9	28.9	28.9
Pelenna House	8.5	12.5	16.4	20.0	23.2	25.1	26.2	26.8	26.8	26.8
Glenview	4.7	8.7	12.6	16.2	19.4	21.3	22.4	23.0	23.0	23.0
Tonmawr Farm	4.9	8.9	12.8	16.4	19.6	21.5	22.6	23.2	23.2	23.2
Railway Terrace	4.5	8.5	12.4	16.0	19.2	21.1	22.2	22.8	22.8	22.8
Brynhyfryd House	4.0	8.0	11.9	15.5	18.7	20.6	21.7	22.3	22.3	22.3
Blaenavon Terrace	3.6	7.6	11.5	15.1	18.3	20.2	21.3	21.9	21.9	21.9

Property	Standardised 10 m Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Uwch-y-Glyn	3.8	7.8	11.7	15.3	18.5	20.4	21.5	22.1	22.1	22.1
Blaenafon Farm	4.0	8.0	11.9	15.5	18.7	20.6	21.7	22.3	22.3	22.3
Jonhs Terrace (end)	3.8	7.8	11.7	15.3	18.5	20.4	21.5	22.1	22.1	22.1
Tynton	8.2	12.2	16.1	19.7	22.9	24.8	25.9	26.5	26.5	26.5
Gyfylchi	4.5	8.5	12.4	16.0	19.2	21.1	22.2	22.8	22.8	22.8

5.5.2 Tables 10 and 11 show predicted contributions from the Pen y Cymoedd Wind Farm and Ffynnon Oer Wind Farm respectively. Table 12 then shows predicted cumulative noise immission levels at each of the selected assessment locations. These predictions are cumulative assuming all other wind farms are operating based on the assumptions summarised in section 5.3 and that all receptors are downwind of all wind turbines at the same time. These cumulative noise levels are unlikely to occur in many conditions.

Table 12 - Predicted cumulative L_{A90} wind farm noise immission levels at each of the noise assessment locations as a function of standardised wind speed

Property	Standardised 10 m Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Fforch-dwm Farm	31.8	35.6	40.0	43.6	44.5	44.6	44.6	44.6	44.6	44.6
Pelenna House	27.8	31.6	36.0	39.7	40.7	40.8	40.9	40.9	40.9	40.9
Glenview	21.4	25.2	29.7	33.6	34.7	34.9	34.9	34.9	34.9	34.9
Tonmawr Farm	21.8	25.6	30.0	33.9	35.0	35.1	35.2	35.2	35.2	35.2
Railway Terrace	21.3	25.0	29.4	33.3	34.4	34.5	34.6	34.6	34.6	34.6
Brynhafryd House	21.1	24.8	29.2	33.0	34.1	34.3	34.4	34.4	34.4	34.4
Blaenavon Terrace	21.7	25.3	29.7	33.5	34.5	34.7	34.7	34.7	34.7	34.7
Uwch-y-Glyn	23.3	26.9	31.2	34.9	35.9	36.0	36.1	36.1	36.1	36.1
Blaenafon Farm	23.6	27.2	31.6	35.2	36.2	36.4	36.4	36.4	36.4	36.4
Jonhs Terrace (end)	23.3	26.9	31.2	34.9	35.9	36.0	36.1	36.1	36.1	36.1
Tynton	22.1	25.9	30.4	34.2	35.4	35.6	35.7	35.8	35.8	35.8
Gyfylchi	22.0	25.8	30.3	34.1	35.2	35.4	35.4	35.4	35.4	35.4

5.6 ETSU-R-97 assessment

5.6.1 Figures C1 to C8 (Annex C) show the calculated wind farm noise immission levels at four representative noise assessment locations, which correspond to those already presented in Table 9 to Table 12 plotted as a function of standardised wind speed. The individual contributions of the different cumulative wind farms considered are also shown. The calculated noise immission levels are shown overlaid on the day-time and night-time noise limits of Tables 4 and 5.

5.6.2 The ETSU-R-97 noise limits assume that the wind turbine noise contains no audible tones. Where tones are present a correction is added to the measured or predicted noise level before comparison with the recommended limits. The audibility of any tones can be assessed by comparing the narrow band level of such tones with the masking level contained in a band of frequencies around the tone called the critical band. The ETSU-R-97 recommendations suggest a tone correction which depends on the amount by which the tone exceeds the audibility threshold and should be included as part of the consent conditions. The turbines to be used for this site will be chosen to ensure that the noise emitted will comply with the requirements of ETSU-R-97 including any relevant tonality corrections.

5.6.3 The assessment (shown in tabular form in Table 13 and Table 14) shows that the predicted cumulative wind farm noise immission levels meet the ETSU-R-97 derived noise limits under all wind speeds and at all locations, based on a lower day-time limit of 40 dB(A). Fforch-dwm Farm is considered a financially involved property and the lower absolute limit is therefore 45 dB(A).

Table 13 - Difference between the ETSU-R-97 derived day time noise limits and the cumulative predicted $L_{A90,T}$ wind farm noise immission levels at each noise assessment location. Values are based on modify lower day time limit and negative values indicate the noise immission level is below the limit.

Property	Standardised 10 m Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Fforch-dwm Farm	-13.2	-9.4	-5.0	-1.4	-0.5	-0.4	-0.4	-0.4	-1.1	-4.3
Pelenna House	-12.9	-10.4	-7.2	-4.4	-4.3	-4.9	-5.4	-5.7	-6.0	-6.0
Glenview	-19.2	-16.8	-13.5	-10.6	-10.3	-10.9	-11.3	-11.7	-11.9	-12.0
Tonmawr Farm	-18.2	-14.4	-10.1	-6.7	-6.1	-6.7	-7.6	-8.6	-9.8	-11.2
Railway Terrace	-18.7	-15.0	-10.7	-7.3	-6.7	-7.3	-8.2	-9.2	-10.4	-11.8
Brynhyfryd House	-18.9	-15.2	-10.9	-7.5	-7.0	-7.6	-8.4	-9.4	-10.7	-12.0
Blaenavon Terrace	-18.3	-14.7	-10.4	-7.1	-6.6	-7.2	-8.1	-9.1	-10.3	-11.7
Uwch-y-Glyn	-16.7	-13.1	-8.9	-5.6	-5.2	-5.8	-6.7	-7.7	-8.9	-10.3
Blaenafon Farm	-16.4	-12.8	-8.5	-5.3	-4.9	-5.5	-6.4	-7.4	-8.6	-10.0
Jonhs Terrace (end)	-16.7	-13.1	-8.9	-5.6	-5.2	-5.8	-6.7	-7.7	-8.9	-10.3
Tynton	-17.9	-14.1	-9.6	-5.8	-4.6	-4.4	-4.9	-7.5	-10.6	-13.9
Gyfylchi	-18.0	-14.2	-9.7	-5.9	-4.8	-4.6	-5.2	-7.9	-10.9	-14.3

Table 14 - Difference between the ETSU-R-97 derived night time noise limits and the cumulative predicted $L_{A90,T}$ wind farm noise immission levels at each noise assessment location. Negative values indicate the immission level is below the limit.

Property	Standardised 10 m Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Fforch-dwm Farm	-13.2	-9.4	-5.0	-1.4	-0.5	-0.4	-0.4	-0.4	-0.4	-1.7
Pelenna House	-15.2	-11.7	-7.7	-4.4	-3.8	-3.9	-4.1	-4.2	-4.2	-4.2
Glenview	-21.6	-18.0	-14.0	-10.6	-9.8	-9.9	-10.1	-10.2	-10.2	-10.2
Tonmawr Farm	-21.2	-17.4	-13.0	-9.1	-8.0	-7.9	-7.8	-7.8	-7.8	-7.8
Railway Terrace	-21.7	-18.0	-13.6	-9.7	-8.6	-8.5	-8.4	-8.4	-8.4	-8.4
Brynhyfryd House	-21.9	-18.2	-13.8	-10.0	-8.9	-8.7	-8.6	-8.7	-8.7	-8.7
Blaenavon Terrace	-21.3	-17.7	-13.3	-9.5	-8.5	-8.3	-8.3	-8.3	-8.3	-8.3
Uwch-y-Glyn	-19.7	-16.1	-11.8	-8.1	-7.1	-7.0	-6.9	-7.0	-7.0	-7.0
Blaenafon Farm	-19.4	-15.8	-11.4	-7.8	-6.8	-6.6	-6.6	-6.6	-6.6	-6.6
Jonhs Terrace (end)	-19.7	-16.1	-11.8	-8.1	-7.1	-7.0	-6.9	-7.0	-7.0	-7.0
Tynton	-20.9	-17.1	-12.6	-8.8	-7.6	-7.4	-7.3	-7.2	-7.2	-7.2
Gyfylchi	-21.0	-17.2	-12.7	-8.9	-7.8	-7.6	-7.6	-7.6	-7.6	-7.6

5.6.4 The consent for PYC Wind Farm stipulates 40 dB(A) to be the relevant fixed component of the limit at surrounding dwellings for the day-time period. This fixed limit value was relevant for PYC Wind Farm on the premise of the significant energy generating capacity, combined with the relatively low number of dwellings in the surrounding area. The Proposed Development will increase the total cumulative energy output, which was already significant from the PYC Wind Farm. Although the Proposed Development is located in closer proximity to additional properties within the settlement of Tonmawr, most of these properties are located upwind of both the proposed and existing wind turbines in the area under the south-westerly wind direction generally prevailing in the UK. This will therefore limit the

duration of exposure for these properties. It therefore follows that 40 dB(A) remains the appropriate fixed component of the day-time period limit for the combined total noise for PYC Wind Farm and the Proposed Development when operating together. This was also agreed in consultation with NPTCBC's specialist consultant (see section 3.5).

- 5.6.5 It is finally concluded that predicted cumulative noise immission levels from the Proposed Development when operating with both PYC Wind Farm and Ffynnon Oer Wind Farm are compliant with the ETSU-R-97 criteria at all locations and all wind speeds.
- 5.6.6 Satisfactory control of cumulative noise immission levels would therefore be achieved through enforcement of the individual consent limits for each of the individual wind farms. Partial site-specific noise limits which apply to the project in isolation) are set out in Table 15. Following the consultation undertaken, these site-specific noise limits were determined on the basis of day-time ETSU-R-97 limit of Table 4, which is the most restrictive of those set out in Tables 4 and 5. The partial limits were then derived by apportioning these total ETSU-R-97 limits in relation to the proportion of predicted noise levels between the Proposed Development and the other sites considered in the cumulative noise assessment. It was verified that the predictions for the Proposed Development (Table 9) are below the proposed limits of Table 15 with a margin of at least 0.4 dB in all cases and at all wind speeds.
- 5.6.7 The resulting partial noise limits are such that compliance of the Proposed Development with these noise limits would maintain the conclusion of the cumulative assessment and result in cumulative levels which do not exceed the derived ETSU-R-97 noise criteria. The selection of the final turbine to be installed at the site should be made on the basis of enabling the relevant specific partial noise limits of Table 15 to be achieved at the surrounding properties.

Table 15 – Specific apportioned day-time LA90 noise limits derived for the Proposed Development.

Property	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
Fforch-dwm Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.7	46.9
Pelenna House	37.9	37.9	38.6	39.9	41.0	42.0	42.9	43.6	44.1	44.5	44.7	44.8
Glenview	36.6	36.6	37.3	38.7	39.8	40.8	41.7	42.4	42.9	43.3	43.5	43.6
Tonmawr Farm	36.6	36.6	36.6	36.6	36.7	37.1	37.7	38.5	39.4	40.4	41.6	43.0
Railway Terrace	36.9	36.9	36.9	36.9	37.0	37.4	38.0	38.8	39.7	40.8	42.0	43.3
Brynhyfryd House	37.2	37.2	37.2	37.2	37.3	37.7	38.3	39.0	39.9	41.0	42.2	43.6
Blaenavon Terrace	37.8	37.8	37.8	37.8	37.9	38.3	38.9	39.7	40.6	41.6	42.9	44.2
Uwch-y-Glyn	38.4	38.4	38.4	38.4	38.5	38.9	39.5	40.3	41.2	42.3	43.5	44.8
Blaenafon Farm	38.5	38.5	38.5	38.5	38.6	39.0	39.6	40.4	41.3	42.3	43.5	44.9
Jonhs Terrace (end)	38.5	38.5	38.5	38.5	38.5	39.0	39.6	40.3	41.2	42.3	43.5	44.9
Tynton	36.2	36.2	36.2	36.2	36.2	36.2	36.2	36.2	36.8	39.5	42.5	45.9
Gyfylchi	36.7	36.7	36.7	36.7	36.7	36.7	36.7	36.7	37.3	40.0	43.1	46.4

5.7 Additional cumulative assessment

- 5.7.1 Predicted operational noise levels can also be considered at other properties located further away from the receptors of Table 3 considered in the above assessment, taking into account consultation comments considered in section 3.5. The locations of the properties considered in the present section are represented in Figure B1 in Annex B.
- 5.7.2 Table B14 in Annex B considers predicted noise levels at Troed-y-Rhiw (easting / northing 284431 / 197426); predicted noise levels from the operational Ffynnon Oer and PYC wind farms at this location vary between 33 and 45 dB LA90, and predicted levels from the Proposed Development are 10 dB or more lower at this location and therefore negligible.

- 5.7.3 To the north of Tonmawr and the Proposed Development, the nearest non-derelict properties are Pen-rhiw-Angharad Uchaf (280103 / 199365) and Pen-rhiw-Angharad Isaf. Predicted noise levels from the Proposed Development at these properties are up to 30 dB LA90 at the highest wind speeds, with the predicted contribution of the PYC Wind Farm of up to 34 dB LA90. This results in predicted cumulative noise levels of up to 36 dB LA90, which are therefore clearly compliant with the lower consent noise limit of 40 dB for PYC, and the contribution of the Proposed Development at least 10 dB below this limit.
- 5.7.4 For properties in Duffryn, both those along the A4107, as well as Hendre Owen Farm (283603 / 195527) which is located on more elevated land south of these properties, predicted noise levels from the Proposed Development in isolation are up to 28 dB LA90. This is more than 10 dB below the lowest consented noise limits for the PYC Wind Farm and therefore represents a negligible contribution.
- 5.7.5 Furthermore, in the latest assessment³⁰ for the Foel Trawsnant Wind Farm, which is located south of Duffryn, predicted noise levels from the Foel Trawsnant Wind Farm at locations such as Hendre Owen Farm are up to 40 dB LA90, and up to 41 dB LA90 at other locations considered in Duffryn. Therefore, the contribution of the Proposed Development (of less than 30 dB LA90) is considered negligible relative to these predicted levels, as well as relative to the applicable noise limits derived in the Foel Trawsnant Wind Farm assessment (which are higher). In addition, the receptors in Duffryn cannot effectively be downwind from both the Proposed Development and the Foel Trawsnant Wind Farm, making these comparisons particularly conservative.
- 5.7.6 The Y Bryn Wind Farm is currently at scoping stage with limited details available, but it would be located south or south-west of the Foel Trawsnant Wind Farm and therefore the same comments would apply as for the Foel Trawsnant Wind Farm and negligible cumulative impacts would be expected. In any case, it would be a matter for the Y Bryn Wind Farm noise assessment to complete an appropriate cumulative assessment accounting for the Proposed Development if considered necessary.
- 5.7.7 In conclusion, no additional significant effects are identified at more distant properties even when accounting for potential cumulative developments in the area.

5.8 Wind turbines: low-frequency Noise, Vibration and Amplitude Modulation

- 5.8.1 Low frequency noise and vibration resulting from the operation of wind farms are issues that have been attracting a certain amount of attention over recent years. Consequently, Annex A includes a detailed discussion of these topics. In summary of the information provided therein, the current recommendation is that ETSU-R-97 should continue to be used for the assessment and rating of operational noise from wind farms.
- 5.8.2 Annex A also discusses the published research on the subject of wind turbine blade swish Amplitude Modulation (or AM). As a consequence of the combined results of this research, and in particular the development by the IOA of an objective technique for identifying and quantifying AM noise, as well as a review of the subjective response to AM noise by a Government-commissioned research group, a penalty-type approach to account for instances of increased AM outside what is expected from 'normal' blade swish has been proposed. Some uncertainty remains at this stage over the application of such a penalty and this will be subject to a period of testing and review over the next few years. The planning condition wording proposed by Mr Bowdler on behalf of NPTCBC nevertheless includes a penalty-type control proposed on the basis of the proposals referenced in Annex A.

5.9 Substation and solar operational noise

- 5.9.1 The proposed on-site substation would mainly comprise enclosed switchgear equipment, which would have negligible noise emissions, but may include a small-scale auxiliary transformer, as well as a standby

³⁰ Planning application reference P2022/0517 to amend the planning consent reference P2014/0825 with changes in size of the turbines and reduction from 11 to 8 turbines. ES Addendum – chapter 11 – Noise, Wood Group, September 2022.

generator (which would only be used for testing and emergency purposes). Operational noise associated with the solar installation would arise from the inverters and lower-voltage transformers associated with the panels. Noise from fixed plant such as this would be assessed in line with the BS 4142:2014 standard³¹. The assessment according to this standard is based on the L_{Aeq} level with the potential addition of penalties to account for some characteristics of the sound.

- 5.9.2 Based on a separation distance of approximately 280 m from substation option 1 to the nearest property, Blaenafon Farm, and assuming a sound power of 80 dB(A) as a worst-case estimate for an auxiliary transformer of this type, this results in potential noise levels of less than 20 dB L_{Aeq} . Even accounting for a penalty of up to 4 dB(A) for a potential “clearly perceptible” tonal content in the noise, this would result in total corrected or “rated” levels no more than 21 dB L_{Ar} from the substation.
- 5.9.3 The extent of the proposed solar area is located approximately 430 m from the nearest dwellings on the north-west side of Tonmawr such as Blaenafon Farm. Chapter 4 of the EIA suggests that the solar array would comprise two containers which would include electrical plant such as a power transformer and potential inverters. Based on experience of other solar installations, these inverter/transformer units would probably be located centrally within the solar array area to minimise energy losses, and therefore located further away from the dwellings. Furthermore, these receptors will in many cases be screened from this plant by the intervening landscape, as well as the solar panels themselves.
- 5.9.4 But on the basis of assuming two central electrical plant units, with a representative sound power of 91 dB(A) each, located respectively 450 and 650 m away (as a worst-case) and neglecting any losses due to screening, this would also result in predicted levels of less than 23 dB L_{Aeq} at receptors such as Blaenafon Farm. Even accounting for a factor of +2 dB for a slightly audible tone this would result in total corrected or “rated” levels no more than 25 dB L_{Ar} for the solar plant.
- 5.9.5 On the above basis, the total rated levels from electrical plant would be estimated to be around 26 dB L_{Ar} from both the substation and solar areas. This is clearly below the typical existing background noise levels of around 35 dB L_{A90} measured in this area west of Tonmawr (Uwch-y-Glyn): see typical background noise levels shown in Figures C7/C8 in Annex C.
- 5.9.6 This would therefore indicate a negligible impact, taking into account the context of the area and the low absolute level of the noise that this would represent. The final design of the substation and solar areas should be specified such that similarly low absolute levels of noise (not exceeding 30 dB L_{Ar}) are achieved in practice by imposition of suitable noise limits to control rated noise levels from these sources.
- 5.9.7 The receptors considered would potentially be exposed during operation to noise from the proposed substation and solar elements as well as wind turbine noise: it is therefore relevant to consider whether there could be additional in-combination noise impacts, although both are assessed under different guidance documents. The predicted levels from the proposed wind turbines would likely arise when receptors are downwind from the turbines, in northerly or north-east wind conditions for properties in Tonmawr which would tend to occur for a minority of the time on average. In addition, these turbine noise levels would only tend to be produced during windy conditions.
- 5.9.8 In contrast, the operational noise levels from the other electrical plant elements considered are assessed in line with BS 4142, which is generally based on background noise levels obtained during quieter conditions with no wind. Operational noise levels from the solar area is likely to meet levels lower than typical background noise levels during quiet periods. There is therefore on balance, based on professional judgement and considering the above factors in terms of duration and likelihood of noise exposure, unlikely to be any significant additional impacts expected when considering these operational noise sources in combination.

³¹ British Standard 4142: 2014-A1 2019 Method for rating and assessing industrial and commercial sound. British Standards Institute. 2014 (amended 2019).

6. Summary of Key Findings and Conclusions

- 6.1.1 This report has presented an assessment of the impacts of construction and operational noise from the Proposed Development on the residents of nearby dwellings.
- 6.1.2 Several residential properties lying around the wind farm have been selected as being representative of the closest located properties to the wind farm. Noise assessments have been undertaken at these properties by comparing predicted construction and operational noise levels with relevant assessment criteria. In the case of construction noise, relevant assessment criteria are in the form of absolute limit values derived from a range of environmental noise guidance. In relation to operational noise, the limits have been derived from historical background noise levels at four surrounding properties, as agreed in consultation with NPTCBC and their appointed consultant.
- 6.1.3 The construction noise assessment has determined that associated levels are expected to be audible at various times throughout the construction programme, but generally remain with acceptable limits such that their temporary impacts are considered of negligible to minor magnitude. The potential noise and vibration from site access track construction works at the closest property in Tonmawr could however represent a moderate impact. Several management and mitigation measures have been proposed to minimise this and reduce the impact to a minor magnitude.
- 6.1.4 Operational noise from the wind farm has been assessed in accordance with the methodology set out in ETSU-R-97, 'The Assessment and Rating of Noise from Wind farms'. This document provides a robust basis for assessing the operational noise of a wind farm as recommended by Planning Policy Wales.
- 6.1.5 It has been demonstrated that both the day-time and night-time noise limits can be satisfied at all assessment properties across all wind speeds. This assessment has been based on the use of robust sound power data for the Vestas V150 6MW wind turbine which is typical of the type and size of turbine which may be considered for this site, and assuming worst case downwind propagation. The assessment has also considered potential cumulative impacts from neighbouring operational wind farms, such as in particular the Pen y Cymoedd Wind Farm in a robust manner.
- 6.1.6 Noise from the proposed substation and solar area can also be controlled to low noise levels representing a negligible impact.
- 6.1.7 In summary, the overall levels of construction noise are considered to represent a minor impact at most, following mitigation. At some locations under some wind conditions and for a certain proportion of the time, the wind farm noise may be audible, which could represent an adverse impact; however, operational noise immission levels comply with the criteria of the guidance commended by planning policy in Wales for the assessment of wind farm noise.

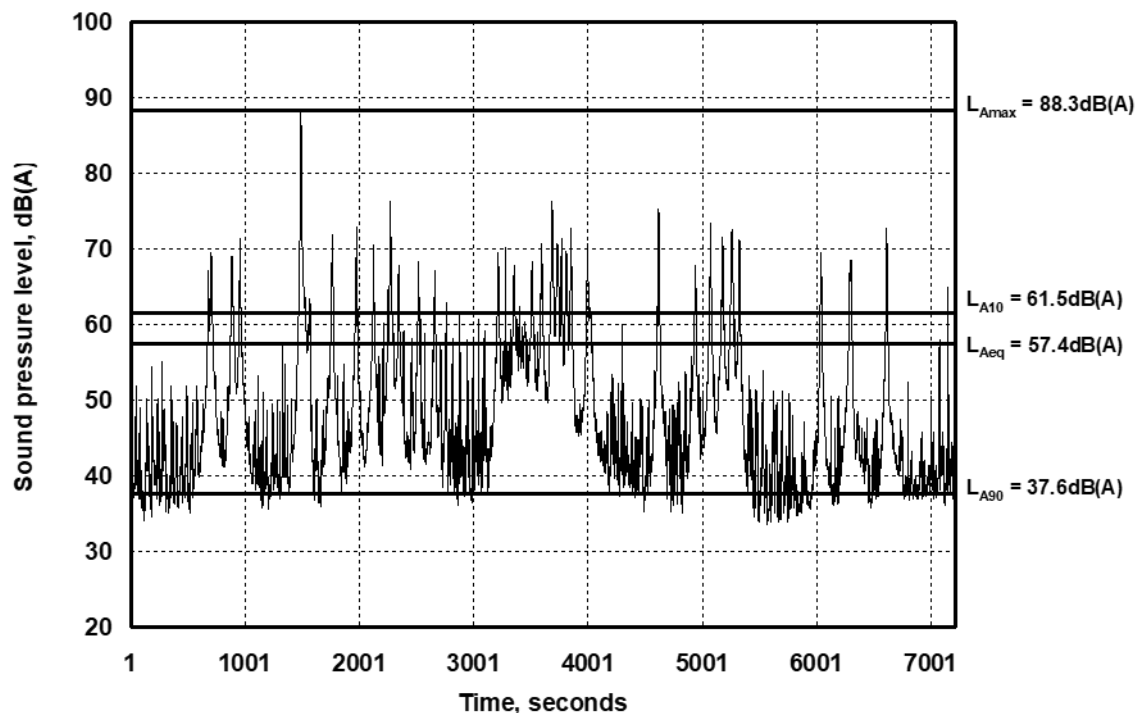
Annex A - General Approach to Noise Assessment & Glossary

- A.1. Some sound, such as speech or music, is desirable. However, desirable sound can turn into unwanted noise when it interferes with a desired activity or when it is perceived as inappropriate in a particular environment.
- A.2. When assessing the effects of sound on humans there are two equally important components that must both be considered: the physical sound itself, and the psychological response of people to that sound. It is this psychological component which results in those exposed differentiating between desirable sound and unwanted noise. Any assessment of the effects of sound relies on a basic appreciation of both these components. This Annex provides an overview of these topics. A glossary of acoustic terminology is included at the end of this Annex.
- A.3. The assessment of environmental noise can be best understood by considering physical sound levels separately from the likely effects that these physical sound levels have on people, and on the environment in general.
- A.4. Physical sound is a vibration of air molecules that propagates away from the source. As acoustic energy (carried by the vibration back and forth of the air molecules) travels away from the source of the acoustic disturbance it creates fluctuating positive and negative acoustic pressures in the atmosphere above and below the standing atmospheric pressure. For most types of sound normally encountered in the environment these acoustic pressures are extremely small compared to the atmospheric pressure. When acoustic pressure acts on any solid object it causes microscopic deflections in the surface. For most types of sound normally encountered in the environment these deflections are so small they cannot physically damage the material. It is only for the very highest energy sounds, such as those experienced close to a jet engine for example, that any risk of physical damage exists. For these reasons, most sound is essentially neutral and has no cumulative damaging physical effect on the environment. The effects of environmental sound are therefore limited to its effects on people or animals.
- A.5. Before reviewing the potential effects of environmental sound on people, it is useful first to consider the means by which physical sound can be quantified.

Indicators of physical sound levels

- A.6. Physical sound is measured using a sound level meter. A sound level meter comprises two basic elements: a microphone which responds in sympathy with the acoustic pressure fluctuations and produces an electrical signal that is directly related to the incident pressure fluctuations, and a meter which converts the electrical signal generated by the microphone into a decibel reading. Figure A1 shows an example of the time history of the decibel readout from a sound level meter located approximately 50 metres from a road. The plot covers a total time period of approximately 2 hours. The peaks in the sound pressure level trace correspond to the passage of individual vehicles past the measurement location.
- A.7. Assigning a single value to the time varying sound pressure level presented in Figure A1 is clearly not straightforward, as the sound pressure level varies by over 50 dB with time. To overcome this, the measurement characteristics of sound level meters can be varied to emphasise different features of the sound that are thought to be most relevant to the effect under consideration.

Figure A1 Sample plot of the sound pressure level measured close to a road over a period of approximately two hours.



Objective measures of noise

- A.8. The primary purpose of measuring environmental noise is to assess its effects on people. Consequently, any sound measuring device employed for the task should provide a simple readout that relates the objectively measured sound to human subjective response. To achieve this, the instrument must, as a minimum, be capable of measuring sound over the full range detectable by the human ear.
- A.9. Perceived sound arises from the response of the ear to sound waves travelling through the air. Sound waves comprise air molecules oscillating in a regular and ordered manner about their equilibrium position. The speed of the oscillations determines the frequency, or pitch, of the sound, whilst the amplitude of oscillations governs the loudness of the sound. A healthy human ear is capable of detecting sounds at all frequencies from around 20 Hz to 20 kHz over an amplitude range of approximately 1,000,000 to 1. Even relatively modest sound level meters are capable of detecting sounds over this range of amplitudes and frequencies, although the accuracy limits of sound level meters vary depending on the quality of the unit. When undertaking measurements of wind turbine noise, as with all other noise measurements, it is important to select a measurement system that possesses the relevant accuracy tolerances and is calibrated to a matching standard.
- A.10. Whilst measurement systems exist that are capable of detecting the range of sounds detected by the human ear, the complexities of human response to sound make the derivation of a likely subjective response from a simple objective measure a non-trivial problem. Not only does human response to sound vary from person to person, but it can also depend as much on the activity and state of mind of an individual at the time of the assessment, and on the 'character' of the sound, as it can on the actual level of the sound. In practice, a complete range of responses to any given sound may be observed. Thus, any objective measure of noise can, at best, be used to infer the average subjective response over a sample population.

Sound levels and decibels

- A.11. Because of the broad amplitude range covered by the human ear, it is usual to quantify the magnitude of sound using the decibel scale. When the amplitude of sound pressure is expressed using decibels (dB) the resultant quantity is termed the sound pressure level. Sound pressure levels are denoted by a capital 'L', as in L dB. The conversion of sound pressure from the physical quantity of Newton per square metre, or Nm⁻², to sound pressure level in dB reduces the range from 0 dB at the threshold of hearing to 120 dB at the onset of pain. Both of these values are derived with respect to the hearing of the average healthy young person.
- A.12. Being represented on a logarithmic amplitude scale, the addition and subtraction of decibel quantities does not follow the normal rules of linear arithmetic. For example, two equal sources acting together produce a sound level 3 dB higher than either source acting individually, so 40 dB + 40 dB = 43 dB and 50 dB + 50 dB = 53 dB. Ten equal sound sources acting together will be 10 dB louder than each source operating in isolation. Also, if one of a pair of sources is at least 10 dB quieter than the other, then it will contribute negligibly to the combined noise level. So, for example, 40 dB + 50 dB = 50 dB.
- A.13. An increase in sound pressure level of 3 dB is commonly accepted as the smallest change of any subjective significance. An increase of 10 dB is often claimed to result in a perceived doubling in loudness, although the basis for this claim is not well founded. An increase of 3 dB is equivalent to a doubling in sound energy, which is the same as doubling the number of similar sources. An increase of 10 dB is equivalent to increasing the number of similar sources tenfold, whilst an increase of 20 dB requires a hundredfold increase in the number of similar sources and an increase of 30 dB requires a thousand times increase in the number of sources.

Frequency selectivity of human hearing and A-weighting

- A.14. Whilst the hearing of a healthy young individual may detect sounds over a frequency range extending from less than 20 Hz to greater than 20 kHz, the ear is not equally sensitive at all frequencies. Human hearing is most sensitive to sounds containing frequency components lying within the range of predominant speech frequencies from around 500 Hz to 4000 Hz. Therefore, when relating an objectively measured sound pressure level to subjective loudness, the frequency content of the sound must be accounted for.
- A.15. When measuring sound with the aim of assessing subjective response, the frequency selectivity of human hearing is accounted for by down-weighting the contributions of lower and higher frequency sounds to reduce their influence on the overall reading. This is achieved by using an 'A'-weighting filter. Over the years, the A-weighting has become internationally standardised and is now incorporated into the majority of environmental noise standards and regulations in use around the world to best replicate the subjective response of the human ear. A-weighting filters are also implemented as standard on virtually all sound measurement systems.
- A.16. Sound pressure levels measured with the A-weighting filter applied are referred to as 'A weighted' sound pressure levels. Results from such measurements are denoted with a subscripted capital A after the 'L' level designation, as in 45 dB LA, or alternatively using a bracketed 'A' after the 'dB' decibel designation, as in 45 dB(A).

Temporal variation of noise and noise indices

- A.17. The simple A-weighted sound pressure level provides a snapshot of the sound environment at any given moment in time. However, as is adequately demonstrated by Figure A1, this instantaneous sound level can vary significantly over even short periods of time. A single number indicator is therefore required that best quantifies subjective response to time varying environmental noise, such as that shown in Figure A1. The question thus arises as to how temporal variations in level should be accounted for. This is most often achieved in practice by selecting a representative time period and calculating either the average noise level over that time period or, alternatively, the noise level exceeded for a stated proportion of that time period, as discussed below.

Equivalent continuous sound level, $L_{Aeq,T}$

- A.18. The equivalent continuous sound level, or $L_{Aeq,T}$ averages out any fluctuations in level over time. It is formally defined as the level of a steady sound which, in a stated time period 'T' and at a given location, has the same sound energy as the time varying sound. The $L_{Aeq,T}$ is a useful 'general' noise index that has been found to correlate well with subjective response to most types of environmental noise.
- A.19. The equivalent continuous sound level is expressed $L_{Aeq,T}$ in dB, where the A-weighting is denoted by the subscripted 'A', the use of the equivalent continuous index is denoted by the subscripted 'eq', and the subscripted 'T' refers to the time period over which the averaging is performed. So, for example, 45 dB $L_{Aeq,1hr}$ indicates that A-weighted equivalent continuous noise level measured over a one hour period was 45 dB.
- A.20. The disadvantage of the equivalent continuous sound level is that it provides no information as to the temporal variation of the sound. For example, an $L_{Aeq,1hr}$ of 60 dB could result from a sound pressure level of 60 dB(A) continuously present over the whole hour's measurement period, or it could arise from a single event of 96 dB(A) lasting for just 1 second superimposed on a continuous level of 30 dB(A) which exists for the remaining 59 minutes and 59 seconds of the hour long period. Clearly, the subjective effect of these two apparently identical situations (if one were to rely solely on the L_{Aeq} index) could be quite different.
- A.21. The aforementioned feature can produce problems where the general ambient noise level is relatively low. In such cases the $L_{Aeq,T}$ can be easily 'corrupted' by individual noisy events. Examples of noisy events that often corrupt $L_{Aeq,T}$ noise measurements in situations of low ambient noise levels include birdsong or a dog bark local to a noise monitoring point, or an occasional overflying aircraft or a sudden gust of wind. This potential downside to the use of $L_{Aeq,T}$ as a general measurement index is of particular relevance to the assessment of ambient noise in quiet environments, such as those typically found in rural areas where wind farms are developed.
- A.22. Despite these shortcomings in low noise environments, the $L_{Aeq,T}$ index is increasingly becoming adopted as the unit of choice for both UK and European guidance and legislation, although this choice is often as much for reasons of commonality between standards as it is for overriding technical arguments. In the Government's current planning policy guidance notes the $L_{Aeq,T}$ noise level is the index of choice for the general assessment of environmental noise. This assessment is undertaken separately for day time ($L_{Aeq,16hr}$ 07:00 to 23:00) and night time ($L_{Aeq,8hr}$ 23:00 to 07:00) periods. However, it is often the case for quiet environments, or for non-steady noise environments, that more information than can be gleaned from the $L_{Aeq,T}$ index may be required to fully assess potential noise effects.

Maximum, L_{Amax} , and percentile exceeded sound level, $L_{An,T}$

- A.23. Figure A1 shows, superimposed on the time varying sound pressure level trace and in addition to the $L_{Aeq,T}$ noise level, examples of three well established measurement indices that are commonly used in the assessment of environmental noise impacts. These are the maximum sound pressure level, L_{Amax} , the 90 percentile sound pressure level, $L_{A90,T}$ and the ten percentile sound pressure level, $L_{A10,T}$.
- A.24. The $L_{Amax,F}$ readings is suited to indicating the physical magnitude of the single individual sound event that reaches the maximum level over the measurement period, but it gives no indication of the number of individual events of a similar level that may have occurred over the time period.
- A.25. Unlike the $L_{Aeq,T}$ index and the $L_{Amax,F}$ indices, percentile exceeded sound levels, percentage exceeded sound levels provide some insight into the temporal distribution of sound level throughout the averaging period. Percentage exceeded sound levels are defined as the sound level exceeded by a fluctuating sound level for n% of the time over a specified time period, T. They are denoted by $L_{An,T}$ in dB, where 'n' can take any value between 0% and 100%.
- A.26. The $L_{A10,T}$ and $L_{A90,T}$ indices are the most commonly encountered percentile noise indices used in the UK.

- A.27. The 10%ile index, or $L_{A10,T}$ provides a measure of the sound pressure level that is exceeded for 10% of the total measurement period. It therefore represents the typical upper level of sound associated with specific events, such as the passage of vehicles past the measurement point. It is the traditional index adopted for road traffic noise. This index is useful because traffic noise is not usually constant, but rather it fluctuates with time as vehicles drive past the receptor location. The $L_{A10,T}$ therefore characterises the typical level of peaks in the noise as vehicles drive past, rather than the lulls in noise between the vehicles.
- A.28. The $L_{A90,T}$ noise index is the noise level exceeded for 90% of the time period, T. It provides an estimate of the level of continuous background noise, in effect performing the inverse task of the $L_{A10,T}$ index by detecting the lulls between peaks in the noise. It is for this reason that the $L_{A90,T}$ noise index is the favoured unit of measurement for wind farm noise where, for the reasons discussed above, the generally low $L_{Aeq,T}$ noise levels are easily corrupted by intermittent sounds such as those produced by livestock, agricultural vehicles or the occasional passing vehicle on local roads. The $L_{A90,T}$ noise level represents the typical lower level of sound that may be reasonably expected to be present for the majority (90%) of the time in any given environment. This is usually referred to as the 'background' noise level.

Temporal variations outside the noise index averaging periods, 'T'

- A.29. Averaging noise levels over the time period 'T' of the $L_{Aeq,T}$ and $L_{An,T}$ noise indices can successfully account for variations in noise over the time period, T. Some variations, however, exhibit trends over longer periods. At larger distances from noise sources meteorological factors can significantly affect received noise levels. At a few hundred metres from a constant level source of noise the potential variation in noise levels may be greater than 15 dB(A). To account for this variability consideration must be taken of meteorological conditions, particularly wind direction, when measurements and predictions are undertaken. As a general rule, when compared with the received noise level under neutral wind conditions, wind blowing from the source to the receiver can slightly enhance the noise level at the receiver (typically by no more than 3 dB(A)), but wind blowing from the receiver to the source can very significantly reduce the noise level at the receiver (typically by 15 dB(A) or more).
- A.30. A similar effect occurs under conditions of temperature inversion, such as may exist after sunset when radiative cooling from the ground lowers the temperature of the air lying at low level more quickly than the air at higher levels, by loss of temperature through convective effects. This results in the air temperature increasing with increasing height above the ground. Depending on the source to receiver distance relative to the heights of the source and receiver, this situation can lead to sound waves becoming 'trapped' in the layer of air lying closest to the ground. The consequence is that noise levels at receptor locations can increase relative to those experienced under conditions of a neutral temperature gradient or a temperature lapse. The maximum increases compared to neutral conditions are similar to those experienced under downwind conditions of no more than around 3 dB(A). It is also worth noting that temperature lapse conditions, which is the more usual situation where temperature decreases with increasing height, can result in reductions in noise level at receptor locations by 15 dB(A) or more compared with the neutral conditions. The similarity between the magnitude of potential variations in noise levels for wind induced and temperature induced effects is not surprising, as the physical mechanisms behind the variations in level are the same for both situations: both variations result from changes in the speed of sound as a function of height above local ground level.
- A.31. Temperature inversions on very still days can also affect noise propagation over much larger distances of several kilometres. These effects can produce higher than expected noise levels even at these very large distances from the source. A classic example that many people have experienced is the distant, usually inaudible, railway train that suddenly sounds like it is passing within a few hundred metres of a dwelling. However, these situations must generally be considered as rare exceptions to the usually encountered range of noise propagation conditions, especially in the case of wind farm noise as they rely on calm wind conditions under which wind turbines do not operate.

Effects of sound on people

- A.32. Except at very high peak acoustic pressures, the energy levels in most environmental sounds are too low to cause any physical disruption in any part of the body, just as they are too low to cause any direct physical damage to the environment. The main effects of environmental sound on people are therefore limited to possible interference with specific activities or to some kind of annoyance response. Some researchers have claimed statistical associations between environmental noise and various long term health effects such as clinical hypertension or mental health problems, although there is no consensus on possible causative mechanisms. Evidence in support of health effects other than annoyance and some indicators of sleep disturbance is weak. However, the theory that psychological stress caused by annoyance might contribute to adverse health effects in otherwise susceptible individuals seems plausible. Health effects in the 'more usual' definition of physiological health therefore remain as a theoretical possibility which has neither been proved nor disproved. However, the World Health Organisation (WHO) defines health in the wider context of:

'a state of complete physical, mental and social well-being and not merely the absence of infirmity'.

And within this wider context potential health effects of environmental noise are summarised by the World Health Organisation as:

- interference with speech communications;
- sleep disturbance;
- disturbance of concentration;
- annoyance; and
- social and economic effects.

Speech interference

- A.33. The instantaneous masking effects of unwanted noise on speech communication can be predicted with some accuracy by using specialist methods of calculation, but the overall effect of a small amount of speech interference on everyday life is harder to judge. The significance of speech masking depends on the context in which it occurs. For example, isolated noise events could interfere with telephone conversations by masking out particular words or parts of words but, because of the high redundancy in normal speech, the masking of individual words can often have no significant effect on the intelligibility of the overall message. Notwithstanding the above, noise levels from wind farms at even the closest located dwellings in otherwise quiet environments are usually no more than around 30 dB(A) indoors, even with windows open. This internal noise level is 5 dB(A) below the 35 dB(A) suggested by the World Health Organisation as the lowest potential cut-on level for issues relating to speech intelligibility.

Sleep disturbance

- A.34. Although sleep seems to be a fundamental requirement for humans, the most significant effect of sleep loss seems to be increased sleepiness the next day. Sleep normally follows a regular cyclic pattern from awake through light sleep to deep sleep and back, this cycle repeating several times during the night at around 90 minute intervals. Most people wake for short periods several times every night as part of the normal sleep cycle without necessarily being aware of this the next day. REM, or rapid eye movement, sleep is associated with dreaming and occurs several times each night during the lighter sleep stages.
- A.35. Electroencephalography (EEG) and similar techniques can be used to detect transient physiological responses to noise at night. Transient responses can be detected by short bursts of activity in the recorded waveforms which often settle back down to the same pattern as immediately before the event. Sometimes a transient response will be the precursor of a definite lightening of sleep, or even of an awakening, but often no discernible physical event happens at all.

- A.36. These results suggest that at least parts of the auditory system remain fully operational even while the listener is asleep. The main purpose of this seems to be to arouse the listener in case of danger or in case some particular action is required which cannot easily be accomplished whilst remaining asleep. On the other hand, the system appears to be designed to filter out familiar sounds which experience suggests do not require any action. A very loud sound is likely to overcome the filtering mechanism and wake the listener, while intermediate and quieter sounds might only wake a listener who has a particular focus on those specific sounds. There is no evidence that the transient physiological responses to noise whilst asleep are anything other than normal. There is also considerable anecdotal evidence that people habituate to familiar noise at night, although some of the research evidence on this point is contradictory.
- A.37. There is no consensus on how much sleep disturbance is significant. Some authorities take a precautionary approach, under which any kind of physiological response to noise is considered important, irrespective of whether there are any next day effects or not. Other studies suggest that transient physiological responses to unfamiliar stimuli at night are merely an indication of normal function and do not need to be considered as adverse effects unless they contribute to significant next-day effects. Recent World Health Organisation guidelines based mainly on laboratory studies suggest indoor limit values of 30 dB L_{Aeq} and 45 dB L_{Amax} to avoid sleep disturbance, while other studies carried out in-situ, where habituation to the noise in question may have occurred, have found that much higher levels can be tolerated without any noticeable ill-effects.

Noise annoyance

- A.38. Noise annoyance describes the degree of 'unwantedness' of a particular sound in a particular situation. People's subjective response to noise can vary from not being bothered at all, through a state of becoming aware of the noise, right through to the point of becoming annoyed by the noise when it reaches a sufficiently high level. There is no statutory definition of noise annoyance.
- A.39. Numerous noise annoyance surveys carried out over the last three decades have attempted to establish engineering relationships between the amount of noise measured objectively using sound level meters and the amount of community annoyance determined from questionnaires. The chief outcome of 'reported annoyance' has been measured using a very large range of different ideas. Both the wording of any questionnaire used and the context in which the question is put, and the manner in which it is therefore interpreted by respondents, can be very important. Some researchers are developing standardised questionnaire formats to encourage greater comparability between different studies, but this does not address the possibility of different contextual effects.
- A.40. Notwithstanding these problems, there is a general consensus that average reported annoyance increases with aggregate noise level in long term static situations. However, there has been comparatively little research and consequently no real agreement on the effects of change. Some studies have found that even small changes in noise level can have unexpectedly large consequences on reported annoyance, while others have found the opposite. The most likely explanation for these apparent discrepancies is that underlying or true annoyance depends on many non-acoustic factors in addition to noise level alone, and that the extent to which reported annoyance actually represents underlying annoyance can be highly dependent on context. As a consequence, attempts to find a common relationship across all noise sources and listening situations have generally floundered. This task has been complicated by the great range of individual sensitivities to noise observed in the surveys, often affected as much by attitude as by noise level.
- A.41. Whether or not an exposed individual has a personal interest in a given sound often has a significant bearing on their acceptance of it. For example, if recipients gain benefit from an association with the sound producer, or if they accept that the sound is necessary and largely unavoidable, then they are likely to be more tolerant of it. This is often the case even if they don't necessarily consider it desirable. A good example of this is road traffic noise which is the dominant noise heard by over 90% of the population but results in relatively few complaints.

- A.42. Notwithstanding the fact that attitudes may be as important as overall levels in determining the acceptance of a particular noise, there still remains a need to objectively quantify any changes in noise level. Whilst it may not be possible to attribute a particular degree of annoyance to a given noise level, an objective measure of noise that bears some relationship to annoyance is still useful. This objective measure enables an assessment of the effect of changes to be assessed on the basis that any reduction in overall noise level must be beneficial. Possible noise mitigation measures form a central consideration of any noise assessment, so an appropriate methodology must be adopted for assessing the effectiveness of any noise mitigation measures adopted.
- A.43. When assessing the potential effects of any new source of noise, it is common practice to compare the A-weighted 'specific' noise level produced by the new source (usually measured using the $L_{Aeq,T}$ index) against the existing A-weighted 'background' noise level measured using the $L_{A90,T}$ index, as this is the typical level of noise that can be reasonably expected to be present the majority of the time to potentially 'mask' the new 'specific' noise. The assessment is therefore undertaken within the context of the existing noise environment. In some circumstances, it may prove equally instructive to compare the absolute level of a new specific noise against accepted absolute levels defined in standards or other relevant documents. The assessment is therefore undertaken against benchmark values, rather than against the context of the existing noise environment. Whatever approach is actually adopted for final assessment purposes, and often a combination of the two approaches is appropriate, it is important that the relevance of both contextual and benchmark assessments is at least considered in all cases.
- A.44. Table 4.1 of the 2000 WHO Guidelines for Community Noise presents guideline benchmark values for environmental noise levels in specific environments. The noise levels relevant to residential dwellings are listed here in Table A1.

Table A1 Relevant extracts from 'Table 4.1 - Guideline Values for Community Noise in Specific Environments'

Specific Environment	Critical Health Effects	$L_{Aeq,T}$	Time base (hrs)	L_{Amax} (dB)
Outdoor living area	Serious annoyance, day time and evening	55	16	-
	Moderate annoyance, day time and evening	50	16	-
Dwelling, indoors	Speech intelligibility and moderate annoyance, day time and evening	35	16	-
	Sleep disturbance, night time	30	8	45
Outside bedrooms	Sleep disturbance, window open (outdoors)	45	8	60
School class rooms (included for potential effects on concentration)	Speech intelligibility, disturbance of information extraction, message communication	35	-	-

- A.45. The text accompanying the Table in the WHO Guidelines explains that the levels given in the Table are set at the lowest levels at which the onset of any adverse health due to exposure to noise has been identified. The text continues:

'These are essentially values for the onset of health effects from noise exposure. It would have been preferred to establish guidelines for exposure-response relationships. Such relationships would indicate the effects to be expected if standards were set above the WHO guideline values and would facilitate the setting of standards for sound pressure levels (noise immission standards).'

- A.46. More recently, Environmental Noise Guidelines for the European Region (2018) were published and include general recommendations for wind turbine noise. However, they are designed to inform policy on noise, at the population and strategic level. They are based on the L_{den} noise indicator, which requires knowledge of the noise levels experienced over the course of a full year. This type of noise index is more suitable for general strategic studies and not appropriate for assessing the acceptability

of noise produced by any specific development. Furthermore, these guidelines do not provide recommendations for indoor noise levels and the 2000 WHO Guidelines for Community Noise remain applicable in this regard. For these reasons, the 2018 guidelines will not be referenced any further.

- A.47. In addition to consideration of the absolute A-weighted level of a new specific source of noise, other properties of the noise can heighten its potential effects when introduced into an existing background noise environment. Such properties of noise are commonly referred to as 'acoustic features' or the 'acoustic character'. These acoustic features can set apart the new source of noise from naturally occurring sounds. Commonly encountered acoustic features associated with transport and machinery sources, for example, can include whistles, whines, thumps, impulses, regular or irregular modulations, high levels of low frequency sound, rumbling, etc.
- A.48. Due to the potential of acoustic features to increase the effects of a noise over and above the effects that would result from an otherwise 'bland' broad band noise of the same A-weighted noise level, it is common practice to add a 'character correction' to the specific noise level before assessing its potential effects. The resulting character corrected specific noise level is often referred to as the 'rated' noise level. Such character corrections usually take the form of adding a number of decibels to the physically measured or calculated noise level of the specific source. Typical character corrections are around +5 dB(A), although the actual correction depends on the subjective significance of the particular feature being accounted for.
- A.49. The objective identification and rating of acoustic features can introduce a requirement to analyse sound in greater detail than has thus far been discussed. To this point all discussion has focussed on the use of the overall A-weighted noise level. This single figure value is derived by summing together all the acoustic energy present in the signal across the entire audible spectrum from around 20 Hz to 20,000 Hz, albeit with the lower and higher frequency contributions down-weighted in accordance with the A-weighting filter characteristics to account for the reduced sensitivity of the human ear at these frequencies.
- A.50. However, in order to identify the presence of tones (which are concentrations of acoustic energy over relatively small bands of frequency), or in order to identify excessive levels of low frequency noise, it may be necessary to determine the acoustic energy present in the noise signal across much smaller frequency bands. This is where the concept of octave band analysis, fractional (e.g. 1/3, 1/12, 1/24) octave band analysis, or even narrow band Fast Fourier Transform (FFT) analysis is introduced. The latter enables signals to be resolved in frequency bandwidths of down to 1 Hz or even less, thereby enabling tonal content to be more easily identified and measured. As standard, noise emission data for wind turbines is supplied as octave band data, with narrow band tests also being undertaken to establish the presence of any tones in the radiated noise spectrum.

Low frequency noise and vibration – wind farms

- A.51. One issue that has increasingly been raised concerning potential noise effects of operational wind farms relates not to the overall noise levels, but to the specific issue of low frequency sound. However, confusion sometimes arises from the use of the generalised term 'low frequency sound' to describe specific effects that may, or sometimes may not, actually relate the low frequency character of the sound itself.
- A.52. In this respect, there are three distinct characteristics of sound that should be clearly differentiated between:
- Low frequency sound in the range from around 20 Hz to 200 Hz, which therefore lies within the commonly referenced range of human hearing of around 20 Hz to 20,000 Hz;
 - Very low frequency sound, or infrasound, below 20 Hz, which therefore lies below the commonly referenced lower frequency limit of human hearing;
 - Amplitude modulated sound that characterises the 'swish, swish' sound sometimes heard from rotating wind turbine blades.

- A.53. Looking at the first two of the three types of sound referred to in the preceding bullet points, a distinction is usually made between low frequency sound and very low frequency sound, otherwise termed infrasound. This distinction is based on the fact that the frequency range of audible noise is generally taken to be from 20 Hz to 20,000 Hz. Therefore, the range of frequencies from about 20 Hz to 200 Hz is usually taken to cover audible low frequency sound, whereas frequencies below 20 Hz are usually described as infrasound. The implication here is that low frequency sound is audible and infrasound is inaudible. However, this relatively arbitrary distinction between low frequency sound and infrasound can introduce some confusion in that frequencies below 20 Hz can still be heard provided they produce a sound pressure level at the ear of the listener that lies above the threshold of audibility of that listener to sound at that particular frequency.
- A.54. The fact that low frequency sound and infrasound from wind farms has been highlighted as a potential problem by some groups does not mean that the wind energy industry had not previously considered the issue. In fact, the issue of low frequency sound was one of the predominant technical hurdles associated with some of the earliest larger scale wind turbines installed in the USA. These turbines were of the 'downwind' type, 'downwind' referring here to the fact that the rotor blades were located downwind of the turbine tower rather than upwind of it, as is the case for current machines. It was found that the interruption of wind flow past the tower resulted in a region of lower than average wind speed immediately in the wake of the tower. The passage of the blades into this region of lower wind speed in the wake of the tower, then back into the higher wind speed as they emerged from the wake of the tower back into the main wind stream, resulted in the generation of low frequency sound, often in the subjective form of a distinctive impulse, often referred to as a 'thump' or 'tower thump'. It was for this reason that modern day turbine configurations now have the blades upwind of the tower, as research and measurements demonstrated that low frequency sound radiation is reduced to sub-audible levels once the interaction of downwind tower wake effects with the rotating blades are removed from the design.
- A.55. One of the problems inherent in the assessment of both low frequency sound and infrasound is the variability of hearing sensitivity across human subjects with otherwise healthy hearing. This threshold for sound below 200 Hz varies significantly more between different subjects than does the hearing threshold at higher frequencies. However, what is always true is that the perception threshold to lower frequency noise is much higher than the perception threshold for speech frequencies between around 250 Hz to 4,000 Hz. For example, the average person with healthy hearing is some 70 dB less sensitive to sounds at 20 Hz than to sounds that fall within the range of speech frequencies. An additional factor relevant to the perception of infrasound is that, although audibility remains below 20 Hz, tonality is lost below 16 Hz to 18 Hz, thus losing a key element of perception.
- A.56. Both low frequency sound and infrasound are generally present all around us in modern life. They may be generated by many natural sources, such as thunder, earthquakes, waves and wind. They may also be produced by machinery including household appliances such as washing machines and air conditioning units, all forms of transport and by turbulence. The presence of low frequency sound and infrasound in our everyday lives is heightened by the fact that the attenuation of sound in air is significantly lower at low frequencies than at the mid to high frequencies. As a result, noise which has travelled over long distances is normally biased towards the low frequencies. However, the fact that human hearing naturally down-weights, or filters out, sounds of such low frequencies means we are generally not aware of its presence. It is only under circumstances when it reaches a sufficiently high level, for example in the 'rumble' of distant thunder or the sound of large waves crashing on a shore, that we become aware of its presence.

A-weighting

- A.57. It is because the human ear increasingly filters out sounds of lower frequencies that environmental noise measurements are undertaken as standard using sound level meters that apply the A-weighting curve, as it filters out lower frequency sounds to the same degree as the hearing of a healthy person with unimpaired hearing. The A-weighted sound level is used as a measure of subjective perception of sound unless there exists such a predominance of low frequency sound or infrasound relative to the

level of sound at higher frequencies that the use of the A-weighting curve would down-weight the actual source of the problem to such a degree that the resultant objective noise levels do not truly reflect the potential subjective effects of the noise. It is for this reason that a number of alternative weighting curves have been developed, specifically aimed at better accounting for the assessment of low frequency sound and infrasound.

Alternative frequency weightings

- A.58. One such curve is denoted C-weighting. Unlike the A weighting curve, which gradually reduces the significance of frequencies below 1000 Hz until at 10 Hz the attenuation is 70 dB, the C-weighting curve is flat to within 1 dB down to about 50 Hz and then drops by 3 dB at 31.5 Hz and 14 dB at 10 Hz. The C weighting curve was originally developed to reflect the fact that, at higher overall noise levels, low frequencies can have a greater subjective effect than at lower overall noise levels.
- A.59. One relatively simple measure of undertaking a first-pass assessment as to whether low frequency sound is likely to be an issue is to determine the difference between the overall C weighted noise level and the overall A weighted noise level. The C weighted level includes contributions from low frequency sound, whereas the A weighted level filters it out. It has been suggested in that a level difference of more than 20 dB indicates that low frequency sound may be subjectively significant, but more detailed investigations are in practice required to determine whether or not this is actually the case.
- A.60. Another curve, termed the G weighting curve, has been specifically derived to provide a measure of the audibility of infrasound when considered separately from higher frequency noise. The G weighting curve falls off rapidly above 20 Hz and below 20 Hz it follows assumed hearing contours with a slope of 12 dB per octave down to 2 Hz.

Wind-farm infrasound and vibration

- A.61. Over the past few years there has been considerable attention paid to the possibility that operational wind farms may radiate sufficiently high levels of infrasound or vibration to cause health problems. Dedicated research investigations have however repeatedly shown this not to be the case.
- A.62. As early as 1997 a report by Snow³² gave details of a comprehensive study of infrasound and low frequency sound (up to around 100 Hz) and vibration measurements made in the vicinity of a wind farm. Measurements were made both on the wind farm site, and at distances of up to 1 kilometre. During the experiments a wide range of wind speeds and directions were recorded. It was found that the vibration levels at 100 metres from the nearest turbine itself were a factor of 10 lower than those recommended for human exposure in the most critical buildings (i.e. laboratories for precision measurements), and lower again than the limits specified for residential premises. A similar comparison with recognised limits for assessing structural damage showed that the measured vibrations were a factor of 100 below the recommended guidelines at 100 metres from the turbines.
- A.63. Noise and vibration levels were found to comply with recommended residential criteria even on the wind turbine site itself. Although low level infrasonic (i.e. below 20 Hz) periodic noise from the wind farm was detected by instrumentation at distances up to 1 kilometre, the measuring instruments used were much more sensitive than human hearing. Based on his measurements Snow concluded that subjective detection of the wind turbines may be apparent at this distance, but if this is the case it will be due to higher frequency components (which are more readily masked by general ambient environmental noise) and not the low frequency components which lie below the threshold of audibility.
- A.64. In 2003, findings on both low frequency sound and infrasound have been compiled into the previously referenced extensive review report commissioned by DEFRA and prepared by Dr G Leventhall³³. Dr Leventhall notes that despite the numerous published studies there is little or no agreement about the

32 'Low frequency noise and vibration measurements at a modern wind farm', D. Snow, ETSU Report ETSU W/13/00392/REP, 1997

33 'A review of published research on low frequency noise and its effects', G. Leventhall, report for DEFRA, 2003

biological effects of infrasound or low frequency sound on human health. Leventhall notes that direct evidence of adverse effects of exposure to low-intensity levels of infrasound (less than 90 dB) is lacking. He goes on to describe the low frequency hearing threshold i.e. the lowest levels which are audible to an average person with normal hearing. He notes the threshold at 4 Hz is about 107 dB, at 10 Hz it is about 97 dB and at 20 Hz it is 79 dB. As such, high levels of infrasound are required to exceed the hearing thresholds at such low frequencies. Leventhall therefore concluded that most people can be reassured that there will be no serious consequences to peoples' health from infrasound exposure.

- A.65. Indeed, specifically in relation to wind farms and infrasound, Leventhall went further still with his statement of reassurance. This additional reassurance followed the voicing of concerns by some interested parties that, because infrasound and very low frequency vibrations could be measured from wind farms, then it must follow that these were a potential hazard and source of annoyance. In fact what those concerned observers failed to account for is that highly sensitive electronic measuring equipment designed solely to detect such infrasonic sounds and vibrations is orders of magnitude more sensitive than even the most sensitive human. Thus, whilst such measurement systems may be able to detect such low-level phenomena, the same stimuli can have no effect on humans. Typical levels of infrasound produced by a wind turbine at representative separation distances would not exceed 70 dB, and clearly below the perception thresholds discussed above. In the light of this, Leventhall issued an open statement:

'I can state quite categorically that there is no significant infrasound from current designs of wind turbines. To say that there is an infrasound problem is one of the hares which objectors to wind farms like to run. There will not be any effects from infrasound from the turbines.'

- A.66. In 2004/2005 researchers from Keele University investigated the effects of the extremely low levels of vibration resulting from wind farms on the operation of a seismic array installed at Eskdalemuir in Scotland. This is one of the most sensitive ground-borne vibration detection stations in the world. The results of this study were initially misinterpreted, as just discussed for the DEFRA/Leventhall report, in that if infrasonic vibrations from wind farms can be measured, then they must consequentially have some potential effect on humans. In order to clarify their position, the authors subsequently explained³⁴ that:

'The levels of vibration from wind turbines are so small that only the most sophisticated instrumentation and data processing can reveal their presence, and they are almost impossible to detect.'

- A.67. They then continue:

'Vibrations at this level and in this frequency range will be available from all kinds of sources such as traffic and background noise – they are not confined to wind turbines. To put the level of vibration into context, they are ground vibrations with amplitudes of about one millionth of a millimetre. There is no possibility of humans sensing the vibration and absolutely no risk to human health.'

- A.68. In relation to airborne infrasound as opposed to ground-borne vibrations, the researchers are equally robust in their conclusions, stating:

'The infrasound generated by wind turbines can only be detected by the most sensitive equipment, and again this is at levels far below that at which humans will detect low frequency sound. There is no scientific evidence to suggest that infrasound [at such an extremely low level] has an impact on human health.'

- A.69. In 2006, the results of a study specifically commissioned by the UK Department of Trade and industry (DTI) to look at the effects of infrasound and low frequency noise (LFN) arising from the operation of wind farms have been published in what is commonly referred to as the DTI LFN Report³⁵. This Report

34 'Wind farm noise', P. Styles, letter by Prof P Styles and S Toon printed in The Scotsman, August 2005.

35 'The measurement of low frequency noise at three UK wind farms', M. Hayes, DTI Report W/45/00656/00, 2006

is quite categorical in its findings: infrasound is not the perceived health threat suggested by some observers, nor should it even be considered a potential source of disturbance. Quoting from the Executive Summary to the DTI LFN Report:

'Infrasound noise emissions from wind turbines are significantly below the recognised threshold of perception for acoustic energy within this frequency range. Even assuming that the most sensitive members of the population have a hearing threshold which is 12 dB lower than the median hearing threshold, measured infrasound levels are well below this criterion.'

The document "Community Noise" prepared for the World Health Organisation, states that "there is no reliable evidence that infrasound below the hearing threshold produce physiological or psychological effects". Other detection mechanisms of infrasound only occur at levels well above the threshold of audibility.'

It may therefore be concluded that infrasound associated with modern wind turbines is not a source which will result in noise levels which may be injurious to the health of a wind farm neighbour'.

- A.70. This has been subsequently confirmed by many international studies and reviews. For example, a study for the National Institute for Public Health and the Environment (RIVM) in the Netherlands³⁶ published in 2020 concluded in this regard that:

'Although low frequency sound and infrasound might have other effects than 'normal' sound has, these effects are highly unlikely at sound levels typical for wind turbines. Brain studies show that low frequency and infrasound are processed in the same parts of the brain as 'normal' sound and there is no evidence that infrasound elicits any reaction at sub-audible levels.'

- A.71. In conclusion, whilst it is known that infrasound can have an adverse effect on people (potential adverse health impacts are listed by the World Health Organisation as stress, irritation, unease, fatigue, headache, possible nausea and disturbed sleep), these effects can only come into play when the infrasound reaches a sufficiently high level. This is a level above the threshold of audibility. However, all available information from measurements on current wind turbines reveals that the level of infrasound emitted by these wind turbines lies below the threshold of human perception.

Low frequency sound

- A.72. A report prepared for DEFRA by Casella Stanger³⁷ lists wind farms as a possible source of audible low frequency sound (20 Hz to 200 Hz). However, this is one possible source in a list of many commonly encountered sources such as pumps, boilers, fans, road, sea and rail traffic, the wind, thunder, the sea, etc. The report only considers the general issues associated with low frequency sound and makes no attempt to quantify the potential problem associated with each of these sources. This is in contrast to other reports which have considered the specific situation associated with wind farms.
- A.73. In respect of low frequency sound as opposed to infrasound, the DTI LFN Report identified that wind farm noise levels at the studied properties were, under certain conditions, measured at a level just above the threshold of audibility. The report therefore concluded that 'for a low frequency sensitive person, this may mean that low frequency sound associated with the operation of the three wind farms could be audible within a dwelling'. This conclusion was, however, placed into some context with the qualifying statement that 'at all measurement sites, low frequency sound associated with traffic movements along local roads has been found to be greater than that from the neighbouring wind farm'. In particular, it was concluded that, although measurable and under some conditions may be audible, levels of low frequency sound were below permitted night time low frequency sound criteria, including the latest UK criteria resulting from the 2003 DEFRA study into the effects of low frequency sound.

36 Health effects related to wind turbine sound: an update, I. van Kamp, G.P. van den Berg, National Institute for Public Health and the Environment (RIVM), RIVM report 2020-0150, October 2020.

37 'Low frequency noise', Report by Casella Stanger for DEFRA, 2001.

- A.74. Based on the findings of the DTI LFN Report, low frequency sound in the greater than 20 Hz frequency range may, under some circumstances, be measured to be of a comparable or higher level than the threshold of audibility. On such occasions this low frequency sound may become audible to low frequency sensitive persons who may already be awake inside nearby properties, but not to the degree that it will cause awakenings. However, such noise should still be assessed for its potential subjective effects in the conventional manner in which environmental noise is generally assessed. In particular, the subjective effects of this audible low frequency sound should not be confused with the claimed adverse health effect arguments concerning infrasound which, in any event, have now been shown from the results of the DTI LFN Report to be wholly unsubstantiated.
- A.75. In November 2006, the UK Government released a statement³⁸ concerning low frequency sound, reiterating the conclusion of the DTI LFN report that:
- 'there is no evidence of health effects arising from infrasound or low frequency sound generated by wind turbines'.*
- A.76. The Government statement concluded the position regarding low frequency sound from wind farms with the definitive advice to all English Local Planning Authorities and the Planning Inspectorate that PPS22 and ETSU-R-97 should continue to be followed for the assessment of noise from wind farms.

Blade swish (amplitude modulation)

- A.77. The noise assessment methodology presented in ETSU-R-97, sets out noise limits which already account for typically encountered levels of blade swish. Notwithstanding the conclusions and advice presented in the preceding paragraphs concerning both infrasound and low frequency sound, the DTI LFN Report went on to suggest that, where complaints of noise at night had occurred, these had most likely resulted from an increased amplitude modulation of the blade passing noise, making the 'swish, swish, swish' sound (often referred to as 'blade swish') more prominent than normal. Whilst it was therefore acknowledged that this effect of enhanced amplitude modulation of blade aerodynamic noise may occur, it was also concluded that there were a number of factors that should be borne in mind when considering the importance to be placed on the issue when considering present and proposed wind farm installations:
- it appeared that the effect had only been reported as a problem at a very limited number of sites (the DTI report looked at the 3 out of 5 U.K. sites where it has been reported to be an issue out of the 126 onshore wind farms reported to be operational at the time in 2006);
 - the effect occurred only under certain conditions at these sites (the DTI LFN Report was significantly delayed while those involved in taking the measurements waited for the situation to occur at each location);
 - at one of the sites concerned it had been demonstrated that the effect can be reduced to an acceptable level by the introduction of a Noise Reduction Management System (NRMS) which controls the operation of the necessary turbines under the relevant wind conditions (this NRMS had to be switched off in order to gain the data necessary to inform the DTI LFN Report);
 - whilst still under review, it appeared that the most likely cause of the increased amplitude modulation was related to an increase in the stability of the atmosphere during evening and night time periods, hence the increased occurrence of such an effect at these times, but this effect had been shown by measurement of wind speed profiles to be extremely site specific;
 - internal noise levels were below all accepted night time criteria limits and insufficient to wake residents, it was only when woken by other sources of a higher level (such as local road traffic) that there were self-reported difficulties in returning to sleep.

38 'Advice on Findings of the Hayes McKenzie Report on Noise Arising from Wind Farms', URN 06/2162 (November 2006).

- A.78. The Government then commissioned an independent research project to further investigate the prevalence of the impact of enhanced levels of amplitude modulation across UK wind farms. This research work was awarded to the University of Salford who reported on their findings in July 2007³⁹. The Salford study concluded that the occurrence of increased levels of 'blade swish' was infrequent, but suggested it would be useful to undertake further work to understand and assess this feature of wind turbine noise.
- A.79. As a consequence of the findings of the report by the University of Salford, the UK Department for Business, Enterprise and Regulatory Reform (BERR formerly the DTI) issued a statement in August 2007⁴⁰ which concluded:-
- 'A comprehensive study by Salford University has concluded that the noise phenomenon known as aerodynamic modulation (AM) is not an issue for the UK's wind farm fleet.*
- AM indicates aerodynamic noise from wind turbines that is greater than the normal degree of regular fluctuation of blade swoosh. It is sometimes described as sounding like a distant train or distant piling operation.*
- The Government commissioned work assessed 133 operational wind projects across Britain and found that although the occurrence of AM cannot be fully predicted, the incidence of it from operational turbines is low'.*
- A.80. The statement then concludes with the advice:
- 'Government continues to support the approach set out in Planning Policy Statement (PPS) 22 – Renewable Energy. This approach is for local planning authorities to "ensure that renewable energy developments have been located and designed in such a way to minimise increases in ambient noise levels", through the use of the 1997 report by ETSU to assess and rate noise from wind energy development'.*
- A.81. This represents an aspect of wind turbine noise which has become the subject of considerable research in the UK and abroad in the past years and the state of knowledge on the subject is rapidly evolving. An extensive research programme entitled 'Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect' was published in 2013⁴¹. This research, commissioned by RenewableUK (ReUK) was specifically aimed at identifying and explaining some of the key features of wind turbine AM noise.
- A.82. Claims have emerged from different researchers that wind turbines were capable of generating noise with characteristics out with that expected of them. This characteristic was an enhanced level of modulated aerodynamic noise that resulted in the blade swish becoming more impulsive in character, such that those exposed to it would describe it more as a 'whoomp' or 'thump' than a 'swish'. It could also become audible at distances from the wind turbines that were considerably greater than the distances at which blade swish could ordinarily be perceived. It has since emerged that this may be similar to the character of the noise identified in the DTI LFN study. Hence for the purposes of the ReUK project, any such AM phenomena with characteristics falling outside those expected of this "normal" AM (NAM) were therefore termed 'Other AM' (OAM).
- A.83. The research identified the most likely cause of OAM noise is transient stall on the wind turbine blade (i.e. stall which occurs over a small area of each turbine blade in one part of the blade's rotation only). The occurrence of transient stall will be dependent on a combination of factors, including the air inflow conditions onto the individual blades, how these inflow conditions may vary across the rotor disc, the design of the wind turbine blades and the manner in which the wind turbine is operated. Variable inflow

39 'Research into Aerodynamic Modulation of Wind Turbine Noise', Report by University of Salford, URN 07/1235 (July 2007)

40 'Government statement regarding the findings of the Salford University report into Aerodynamic Modulation of Wind Turbine Noise', BERR, Ref: 2007/033 (1st August 2007)

41 Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect, Renewable UK, December 2013.

conditions may arise, for example, from any combination of wind shear, wind veer, yaw errors, turbine wake effects, topographic effects, large scale turbulence, etc. However, the occurrence of OAM on any particular site cannot be predicted at this stage.

- A.84. As a consequence of the combined results of the ReUK research, and most notably the development of objective techniques for identifying and quantifying AM noise and the ability to relate such an objective measure to the subjective response to AM noise, ReUK has proposed an AM test⁴² for implementation as a planning condition, although this was subject to discussion.
- A.85. The Institute of Acoustics (IOA) published in 2016 a standardised methodology⁴³ for the assessment and rating of AM magnitude. The method provides a decibel level each 10 minute which represents the magnitude of the modulation in the noise, and minimises the influence of sources not related to wind turbines. The proposed method, unlike other methods that have previously been proposed, utilises as the core of its detection capability the fact that AM noise from wind turbines, by definition, exhibits periodicity at a rate that is directly related to the rotational speed of the source wind turbine. The IOA document does not however provide any thresholds or criteria methodology for using the resulting AM values.
- A.86. The UK Government (DECC or Department of Energy and Climate Change, now obsolete) commissioned a review focused on the subjective response to AM with a view to recommend how this feature may be controlled. The outcome of this research has been published⁴⁴ in October 2016 by the Department for Business, Energy & Industrial Strategy (DBEIS). This report recommends the use of a “character penalty” approach, in which a correction is applied to the overall A-weighted noise level to account for AM in the noise in a manner similar to that used to assess tonality in the noise according to ETSU-R-97. This penalty is based on the above IOA methodology for detecting AM. The researchers make a number of recommendations for local authorities to consider and qualifications for the use of such controls, and note that the current state of knowledge on the subject and the implications of their proposed control is limited and that a period of testing and review over the next few years would be beneficial. The authors were however unable to provide clarity on how exactly the recommendations would operate in practice for any particular wind farm. On publication of the report, DBEIS encouraged local authorities in England to consider the research but provided limited guidance on how the outcomes were to be accounted for within the planning system. The Scottish Government is understood to be reviewing this report in the context of the Scottish planning system⁴⁵. There is currently no specific guidance from the Welsh Government on this topic.

42 Template Planning Condition on Amplitude Modulation (guidance notes), RenewableUK, December 2013.

43 Institute of Acoustics (IOA) Amplitude Modulation Working Group, Final Report, A Method for Rating Amplitude Modulation in Wind Turbine Noise, June 2016.

44 Review of the evidence on the response to amplitude modulation from wind turbines, WSP for Department for Business, Energy & Industrial Strategy. <https://www.gov.uk/government/publications/review-of-the-evidence-on-the-response-to-amplitude-modulation-from-wind-turbines>

45 Scottish Government (2021) - Onshore wind - policy statement refresh 2021: consultative draft, 28 October 2021.

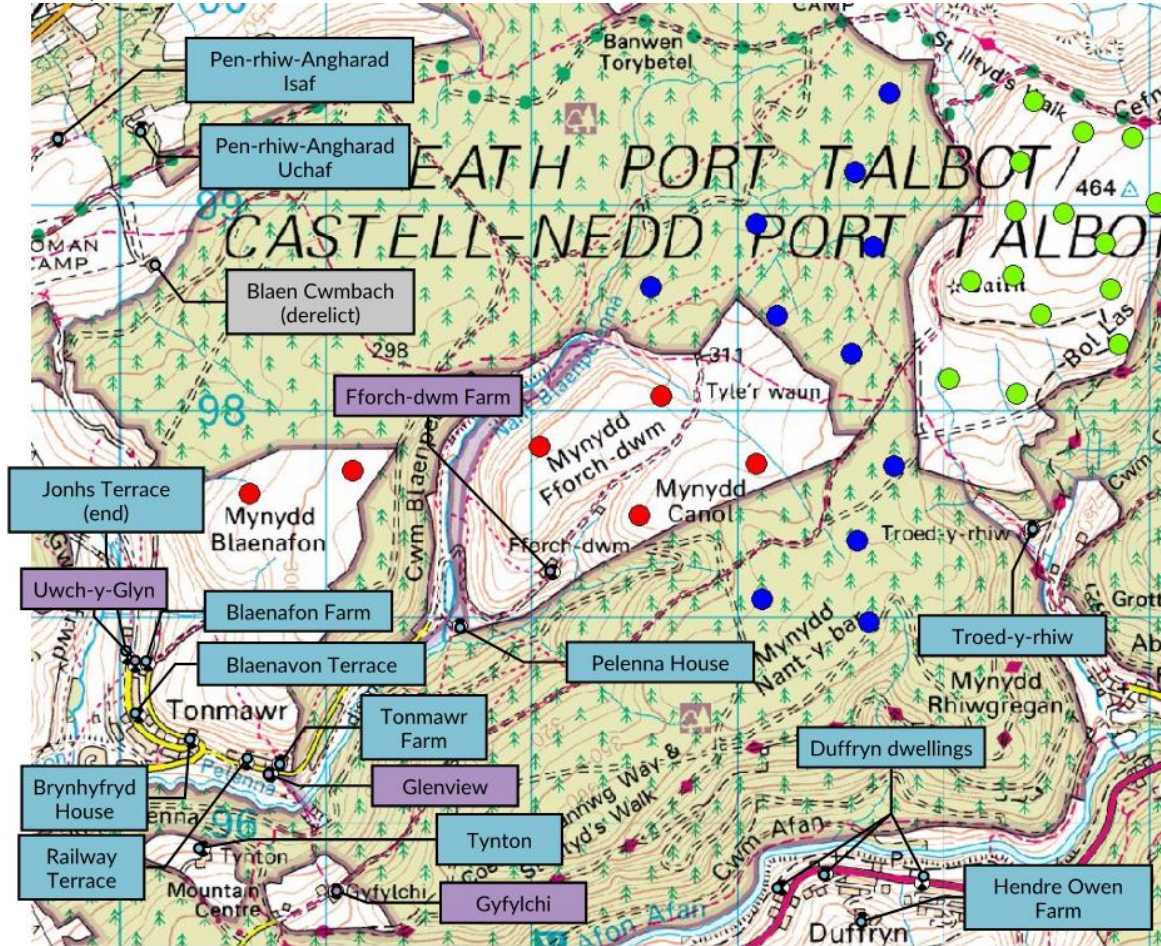
Glossary of Acoustics Terminology

Terminology	Description
A-weighting	A filter that down-weights low frequency and high frequency sound to better represent the frequency response of the human ear when assessing the likely effects of noise on humans
Acoustic character	One or more distinctive features of a sound (e.g. Tones, whines, whistles, impulses) that set it apart from the background noise against which it is being judged, possibly leading to a greater subjective effect than the level of the sound alone might suggest
Acoustic screening	The presence of a solid barrier (natural landform or manmade) between a source of sound and a receiver that interrupts the direct line of sight between the two, thus reducing the sound level at the receiver compared to that in the absence of the barrier
Ambient noise	All-encompassing noise associated with a given environment, usually a composite of sounds from many sources both far and near, often with no particular sound being dominant
Annoyance	A feeling of displeasure in this case evoked by noise
Attenuation	The reduction in level of a sound between the source and a receiver due to any combination of effects including: distance, atmospheric absorption, acoustic screening, the presence of a building façade, etc.
Audio frequency	Any frequency of a sound wave that lies within the frequency limits of audibility of a healthy human ear, generally accepted as being from 20 Hz To 20,000 Hz
Background noise	The noise level rarely fallen below in any given location over any given time period, often classed according to day time, evening or night time periods (for the majority of the population of the UK the lower limiting noise level is usually controlled by noise emanating from distant road, rail or air traffic)
Db	Abbreviation for 'decibel'
Db(a)	Abbreviation for the decibel level of a sound that has been a-weighted
Decibel	The unit normally employed to measure the magnitude of sound
Directivity	The property of a sound source that causes more sound to be radiated in one direction than another
Equivalent continuous sound pressure level	The steady sound level which has the same energy as a time varying sound signal when averaged over the same time interval, t, denoted by $L_{Aeq,t}$
External noise level	The noise level, in decibels, measured outside a building
Filter	A device for separating components of an acoustic signal on the basis of their frequencies
Frequency	The number of acoustic pressure fluctuations per second occurring about the atmospheric mean pressure (also known as the 'pitch' of a sound)
Frequency analysis	The analysis of a sound into its frequency components
Ground effects	The modification of sound at a receiver location due to the interaction of the sound wave with the ground along its propagation path from source to receiver
Hertz	The unit normally employed to measure the frequency of a sound, equal to cycles per second of acoustic pressure fluctuations about the atmospheric mean pressure
Impulsive sound	A sound having all its energy concentrated in a very short time period
Instantaneous sound pressure	At a given point in space and at a given instant in time, the difference between the instantaneous pressure and the mean atmospheric pressure
Internal noise level	The noise level, in decibels, measured inside a building
L_{Aeq}	The abbreviation of the a-weighted equivalent continuous sound pressure level
L_{A10}	The abbreviation of the 10 percentile noise indicator, often used for the measurement of road traffic noise
L_{A90}	The abbreviation of the 90 percentile noise indicator, often used for the measurement of background noise
Level	The general term used to describe a sound once it has been converted into decibels
Loudness	The attribute of human auditory response in which sound may be ordered on a subjective scale that typically extends from barely audible to painfully loud
Noise	Physically: a regular and ordered oscillation of air molecules that travels away from the source of vibration and creates fluctuating positive and negative acoustic pressure above and below atmospheric pressure.

Terminology	Description
	Subjectively: sound that evokes a feeling of displeasure in the environment in which it is heard, and is therefore unwelcomed by the receiver
Noise emission	The noise emitted by a source of sound
Noise immission	The noise to which a receiver is exposed
Noise nuisance	An unlawful interference with a person's use or enjoyment of land, or of some right over, or in connection with it
Octave band frequency analysis	A frequency analysis using a filter that is an octave wide (the upper limit of the filter's frequency band is exactly twice that of its lower frequency limit)
Percentile exceeded sound level	The noise level exceeded for n% of the time over a given time period, t, denoted by $L_{An,t}$
Receiver	A person or property exposed to the noise being considered
Residual noise	The ambient noise that remains in the absence of the specific noise whose effects are being assessed
Sound	Physically: a regular and ordered oscillation of air molecules that travels away from the source of vibration and creates fluctuating positive and negative acoustic pressure above and below atmospheric pressure Subjectively: the sensation of hearing excited by the acoustic oscillations described above (see also 'noise')
Sound level meter	An instrument for measuring sound pressure level
Sound pressure amplitude	The root mean square of the amplitude of the acoustic pressure fluctuations in a sound wave around the atmospheric mean pressure, usually measured in pascals (Pa)
Sound pressure level	A measure of the sound pressure at a point, in decibels
Sound power level	The total sound power radiated by a source, in decibels
Spectrum	A description of the amplitude of a sound as a function of frequency
Standardised wind speed	Values of wind speed at hub height corrected to a standardised height of ten metres using the same procedure as used in wind turbine emission testing
Threshold of hearing	The lowest amplitude sound capable of evoking the sensation of hearing in the average healthy human ear (0.00002 Pa)
Tone	The concentration of acoustic energy into a very narrow frequency range

Annex B – Location Maps and Turbine Coordinates

Figure B1 Map showing the layout of the Proposed Development turbines (red circles), the Pen-y-Cymoedd wind turbines (blue), the Ffynnon Oer wind turbines (green), the historical noise monitoring locations (purple call-outs) and the additional noise assessment locations (blue call-outs).



Turbine & Propagation Details: the Proposed Development

- B.1. All turbines of the Proposed Development (Table B1) were modelled at representative hub heights between 105 and 125 m, using the Vestas V150 6MW candidate turbine. Terrain propagation effects are also set out in Table B6 for the closest turbines to the Proposed Development.
- B.2. Vestas has supplied their specification noise emission data for the V150 6MW wind turbine, which represent the values that the manufacturer expects to be emitted in practice. In the absence of specific information about uncertainty allowances in the data, a further correction factor of +2 dB was added to the specification data in line with advice in the IOA GPG. The Vestas sound power data has been made available for hub height wind speeds and converted to standardised reference wind speeds between 3 m/s and 12 m/s inclusive, at a number of standard hub heights: see Table B3. As set out in Table B1, the noise emission of each turbine was based on the corresponding hub height noise or the closets highest value.
- B.3. In addition to the overall sound power data, reference has been made to the Vestas specification documentation to derive a representative sound spectrum for the turbine, based on the available information: the resulting spectral data is presented in Tables B4.

Table B1 – Turbine coordinates – the Proposed Development

Turbine	Easting	Northing	Hub Height modelled	Hub Height noise data referenced (Table B3)
T1	281131	197711	105	105
T2	280629	197599	105	105
T3	283088	197744	125	125
T4	282628	198074	125	125
T5	282522	197493	125	125
T6	282036	197830	125	125

Table B2-Propagation attenuation effects due to terrain (dB) – the Proposed Development – Positive numbers are due to terrain shielding barrier effects (e.g. 2), representing a decrease in noise levels, and negative numbers (e.g. -3) represent an increase in predicted noise levels due to concave ground effects. Where there is a zero shown, neither terrain shielding nor concave ground were found.

Turbine	Property											
	Fforch-dwm Farm	Pelenna House	Glenview	Tonmawr Farm	Railway Terrace	Brynhfryd House	Blaenavon Terrace	Uwch-y-Glyn	Blaenafon Farm	Jonhs Terrace (end)	Tynton	Gyfylchi
T1	0	0	2	2	2	2	2	0	0	0	0	-3
T2	0	2	2	2	2	2	0	0	0	0	0	0
T3	0	2	2	2	2	2	2	2	2	2	-3	0
T4	0	2	2	2	2	2	2	2	2	2	0	0
T5	0	0	2	2	2	2	2	2	2	2	-3	0
T6	0	0	2	2	2	2	2	2	2	2	-3	-3

Table B3 - Wind turbine sound power levels (dB L_{Aeq}) used in the noise assessment - the Proposed Development

Turbine make / model	Standardised 10 m Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Vestas V150, 105m Hub Height	94.8	98.2	102.5	106.0	106.8	106.9	106.9	106.9	106.9	106.9
Vestas V150, 125m Hub Height	95.0	98.6	103.0	106.3	106.8	106.9	106.9	106.9	106.9	106.9
Derived from: <i>Vestas Document V150-6.0MW Third Octaves, 0095-3747.V01</i>										

Table B4 - Octave band sound power spectrum (dB L_{Aeq}) for reference wind speed conditions (v₁₀ = 8 m/s) - the Proposed Development (normalised to 100 dB(A))

Turbine make / model	Octave Band Centre Frequency (Hz)								
	63	125	250	500	1000	2000	4000	8000	A
Vestas V150 6MW	81.1	88.7	93.4	95.1	94	89.9	82.9	72.9	100
Derived from: <i>Vestas Document V150-6.0MW Third Octaves, 0095-3747.V01</i>									

Turbine & Propagation Details: Pen-y-Cymoedd

- B.4. The Pen-y-Cymoedd (PYC) Wind Farm is built and operating. Coordinates for the PYC turbines relate to the planning permission under Section 36 of the Electricity Act⁴⁶ for 76 turbines (numbered and prefixed 'PC'). Noise limits for the wind farm are based on the greater of 40 dB(A) or 5 dB above background noise levels day-time or the greater of 43 dB(A) or 5 dB(A) above background noise levels night-time, as set out in tables attached to condition 28 of the consent. As-built turbine coordinates for the PYC Wind Farm are set out in Table B5: these comprise a mix of Siemens SWT-3.0-108 and SWT-3.0-113 turbine models, with a hub height of 89.5 m. Terrain propagation effects are also set out in Table B6 for the closest turbines to the Proposed Development (given the scale of the PYC scheme and the limited effects of these factors for more distant turbines).
- B.5. Sound power levels for the PYC wind turbines are taken from Siemens documents for the installed wind turbine models as referenced in the tables below. In the absence of specific information about uncertainty allowances in the data, a correction factor of +2 dB was added to the Siemens specification data in line with advice in the IOA GPG. The resulting data is set out in Table B7. In addition, reference was made to the Siemens documentation for a representative sound spectrum for the turbine: this is set out in Table B8.
- B.6. As discussed in section 3.2 and 3.5 of the main report above, it is also necessary to consider the potential noise allowed under the consent for the Pen-y-Cymoedd Wind Farm at neighbouring properties. For the properties considered in the assessment, the relevant controlling property, i.e. closest to the PYC turbines, is Fforch-dwm Farm. Table B9 sets out the consent noise limits for PYC at this property, which is not financially involved with PYC (although it is involved with the Proposed Development). Based on the noise emission levels of Table B7/B8, the total noise from all PYC turbines at Fforch-dwm Farm was calculated to be 37.4 dB(A) at a critical wind speed of 7 m/s (where predicted noise levels are closest to the noise limit), where the consent noise limit is 40 dB(A) for day-time periods.
- B.7. Therefore, a further uplift of +2.6 dB was added to the noise emission levels of Table B7/B8 for all turbines of the PYC Wind Farm as a basis for the cumulative analysis. This means that the predictions at Fforch-dwm Farm for PYC only just meet the consent noise limit at this controlling property: this is illustrated in Figure C1 below. This therefore represents a robust basis for the cumulative noise analysis, as required by the IOA GPG.

Table B5 – Turbine coordinates – Pen-y-Cymoedd Wind Farm

Turbine	Easting	Northing	Turbine	Easting	Northing	Turbine	Easting	Northing
PC1	283758	197736	PC27	289171	201847	PC53	289720	199315
PC2	283576	197373	PC28	289158	202334	PC54	289739	200000
PC3	283631	196974	PC29	290073	202375	PC55	289957	199021
PC4	283117	197088	PC30	290065	202716	PC56	289645	198550
PC5	283186	198462	PC31	289923	203103	PC57	290245	198410
PC6	282577	198604	PC32*	290394	202086	PC58	290334	198748
PC7*	283086	198907	PC33*	290814	202505	PC59*	292897	202369
PC8*	283565	199158	PC34*	291105	202210	PC60*	293106	202803

46 Department of Energy and Climate Change, National Infrastructure Consents. Construction and operation of a wind turbine generating station on land to the south of the Heads of The Valley Road between Neath and Aberdare, south Wales. Consent under Section 36 of the Electricity Act 1989, 8 May 2012.

Turbine	Easting	Northing	Turbine	Easting	Northing	Turbine	Easting	Northing
PC9*	283732	199540	PC35*	290831	201822	PC61*	293511	203137
PC10*	283656	198797	PC36*	291349	201872	PC62*	293484	202482
PC11	283548	198280	PC37*	291105	201484	PC63*	293934	202871
PC12	287885	202459	PC38	290227	201675	PC64*	294365	202735
PC13	287453	202133	PC39	290020	201267	PC65*	294656	202427
PC14	286904	201486	PC40	290544	201445	PC66*	293668	202160
PC15	286470	200959	PC41	290612	201100	PC67*	294203	202094
PC16	286095	200716	PC42	290994	200923	PC68*	293935	201766
PC17	285475	200635	PC43	290617	200693	PC69*	294433	201531
PC18	285686	200292	PC44	290774	200392	PC70*	293076	202032
PC19	287553	201662	PC45	291314	200508	PC71*	293364	201654
PC20	287998	201967	PC46	290099	200411	PC72*	293645	201279
PC21	288394	202352	PC47	290320	200082	PC73*	294197	201042
PC22	288762	202756	PC48	290669	199844	PC74*	294484	200779
PC23	289323	202880	PC49	290418	199524	PC75*	294570	200361
PC24	288652	201997	PC50	290871	199360	PC76*	294571	199984
PC25	288610	201642	PC51	291196	199756			
PC26	288845	201329	PC52	289959	199691			

All turbines modelled with a 98.5 m hub height. *Siemens SWT-3.0-108 installed, other turbines are SWT-3.0-113.

Table B6-Propagation attenuation effects due to terrain (dB) – Pen-y-Cymoedd Wind Farm (closest 10 turbines only). Positive numbers are due to terrain shielding barrier effects (e.g. 2), representing a decrease in noise levels, and negative numbers (e.g. -3) represent an increase in predicted noise levels due to concave ground effects. Where there is a zero shown, neither terrain shielding nor concave ground were found.

Turbine	Property											
	Fforch-dwm Farm	Pelenna House	Glenview	Tonmawr Farm	Railway Terrace	Brynhfryd House	Blaenavon Terrace	Uwch-y-Glyn	Blaenafon Farm	Jonhs Terrace (end)	Tynton	Gyfylchi
PC1	0	2	2	2	2	2	2	2	2	2	0	2
PC2	0	0	2	2	2	2	2	2	2	2	0	2
PC3	0	0	0	0	2	2	2	2	2	2	0	2
PC4	0	0	0	0	2	2	2	2	2	2	-3	0
PC5	0	2	2	2	2	2	2	2	2	2	0	0
PC6	2	2	2	2	2	2	2	2	2	2	0	0

Turbine	Property											
	Fforch-dwm Farm	Pelenna House	Glenview	Tonmawr Farm	Railway Terrace	Brynhyfryd House	Blaenavon Terrace	Uwch-y-Glyn	Blaenafon Farm	Jonhs Terrace (end)	Tynton	Gyfylchi
PC7*	2	2	2	2	2	2	2	2	2	2	0	0
PC8*	2	2	2	2	2	2	2	2	2	2	2	0
PC9*	2	2	2	2	2	2	2	2	2	2	2	0
PC10*	2	2	2	2	2	2	2	2	2	2	0	2
PC11	2	2	2	2	2	2	2	2	2	2	-3	0

Table B7 - Wind turbine sound power levels (dB L_{Aeq}) used in the noise assessment – Pen-y-Cymoedd Wind Farm. All values for 89.5 m hub height. Please note that a further uplift of +2.6 dB was added in the calculations in addition to the values set out in this table.

Turbine make / model	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
SWT-3.0-113	-	-	92.7	97.2	101.8	106.2	107.5	107.5	107.5	107.5	107.5	107.5
SWT-3.0-108	-	-	93.0	97.2	101.9	106.5	108.7	109.0	109.0	109.0	109.0	109.0

Derived from: Siemens documents Standard Acoustic Emission, SWT-3.0-108, Rev. 1 (0000-B821-00) and Standard Acoustic Emission, SWT-3.0-113, Rev. 0 (0000-B824-00), dated 16/12/2014.

Table B8 - Octave band sound power spectrum (dB L_{Aeq}) for reference wind speed conditions (v₁₀ = 8 m/s) - Pen-y-Cymoedd Wind Farm.

Turbine make / model	Octave Band Centre Frequency (Hz)								
	63	125	250	500	1000	2000	4000	8000	A
SWT-3.0-113	89.0	92.6	95.7	95.8	96.8	95.9	92.7	83.4	103.2
SWT-3.0-108	85.5	93.0	100.4	103.7	100.4	92.5	81.6	78.3	107.0

Derived from: Derived from: Siemens documents Standard Acoustic Emission, SWT-3.0-108, Rev. 1 (0000-B821-00) and Standard Acoustic Emission, SWT-3.0-113, Rev. 0 (0000-B824-00), dated 16/12/2014.

Table B9 - Pen-y-Cymoedd Wind Farm - consented noise limits (L_{A90}, dB) at Fforch-dwm Farm.

Property/period	Standardised 10 m Wind Speed (m/s)						
	4	5	6	7	8	9	10
Fforch-dwm Farm – day-time	40	40	40	40	41	43	45
Fforch-dwm Farm – night-time	43	43	43	43	43	45	45

Turbine & Propagation Details: Ffynnon Oer

- B.8. The Ffynnon Oer Wind Farm is operational and comprises 16 turbines, located 1.5 km east of the Proposed Development, and east of the PYC wind turbines. The installed turbines are RePower MM70 wind turbines model, with a hub height of 58 m. Sound power data for the MM70 turbine operating in its unconstrained mode of operation was derived from a RePower warranty document (see Table B11). Comparison of this data with several test reports for the turbines confirmed that this data incorporated an allowance for uncertainty in line with IOA GPG requirements and therefore represents a robust basis for the analysis. A representative spectrum was also obtained using a test report for the turbine: see Table B12. Table B13 shows that the Ffynnon Oer Wind Farm turbines are screened by the terrain from almost all of the properties considered in the assessment.
- B.9. The closest property to the Ffynnon Oer Wind Farm is Troed-y-Rhiw (easting / northing 284431 / 197426) which is located south of Ffynnon Oer Wind Farm but more than 1 km east of the Proposed Development turbines. It is not clear if the Ffynnon Oer Wind Farm has consent noise limits it needs to meet at this property, but the wind turbine predictions at this property are in any case clearly dominated by the PYC Wind Farm: see Table B14 below. This shows that, on the basis of the assumptions above, predicted noise levels for the total noise from Ffynnon Oer and PYC are close to the consent noise limits for PYC.
- B.10. In any case, noise levels from PYC could not be higher than those assumed without exceeding the relevant noise limits at Fforch-dwm Farm, the controlling property closest to the Proposed Development (as outline above). At this property, predicted noise levels from Ffynnon Oer Wind Farm are below 29 dB L_{A90} and therefore represent a negligible contribution to total noise levels relative to the other wind farms considered. At other properties further away, the contribution would be lower still (as is clear from the charts of Annex C). There is therefore no need to consider a further addition of an increased margin on the emission levels of the turbines at Ffynnon Oer Wind Farm as this would not alter the outcome at the relevant properties and would lead to excessive noise levels at Troed-y-Rhiw, the nearest relevant property.

Table B10 – Turbine coordinates – Ffynnon Oer Wind Farm

Turbine	Easting	Northing	Turbine	Easting	Northing
F1	284353	198083	F9	284437	199504
F2	284024	198154	F10	284368	199210
F3	284845	198321	F11	284347	198969
F4	284810	198591	F12	284580	198959
F5	285032	199006	F13	284778	198813
F6	285133	199244	F14	284337	198660
F7	284916	199324	F15	284469	198466
F8	284673	199353	F16	284130	198628

Table B11 - Wind turbine sound power levels (dB L_{Aeq}) used in the noise assessment – Ffynnon Oer Wind Farm. All values for 58 m hub height.

Turbine make / model	Standardised 10 m Wind Speed (m/s)											
	1	2	3	4	5	6	7	8	9	10	11	12
RePower MM70	-	88.5	88.7	92.7	96.6	100.2	103.4	105.3	106.4	107.0	107.0	107.0

Derived from: RePower warranty document 30/11/2004.

Table B12 - Octave band sound power spectrum (dB L_{Aeq}) for reference wind speed conditions (v₁₀ = 8 m/s) - Ffynnon Oer Wind Farm.

Turbine make / model	Octave Band Centre Frequency (Hz)								
	63	125	250	500	1000	2000	4000	8000	A
RePower MM70	82.8	92.1	97.0	96.3	99.0	99.3	95.4	81.9	104.9
Derived from: Windtest WT 2711/03 test report summary at 10m/s.									

Table B13-Propagation attenuation effects due to terrain (dB) – Ffynnon Oer Wind Farm. Positive numbers are due to terrain shielding barrier effects (e.g. 2), representing a decrease in noise levels, and negative numbers (e.g. -3) represent an increase in predicted noise levels due to concave ground effects. Where there is a zero shown, neither terrain shielding nor concave ground were found.

Turbine	Property											
	Fforch- dwm Farm	Pelenna House	Glenview	Tonmawr Farm	Railway Terrace	Brynhafod House	Blaenavon Terrace	Uwch-y- Glyn	Blaenafon Farm	Jonhs Terrace (end)	Tynton	Gyflychi
F1	2	2	2	2	2	2	2	2	2	2	0	2
F2	2	2	2	2	2	2	2	2	2	2	-3	2
F3	2	2	2	2	2	2	2	2	2	2	-3	2
F4	2	2	2	2	2	2	2	2	2	2	-3	2
F5	2	2	2	2	2	2	2	2	2	2	-3	2
F6	2	2	2	2	2	2	2	2	2	2	-3	2
F7	2	2	2	2	2	2	2	2	2	2	-3	2
F8	2	2	2	2	2	2	2	2	2	2	-3	2
F9	2	2	2	2	2	2	2	2	2	2	-3	2
F10	2	2	2	2	2	2	2	2	2	2	-3	2
F11	2	2	2	2	2	2	2	2	2	2	-3	2
F12	2	2	2	2	2	2	2	2	2	2	-3	2
F13	2	2	2	2	2	2	2	2	2	2	-3	2
F14	2	2	2	2	2	2	2	2	2	2	-3	2
F15	2	2	2	2	2	2	2	2	2	2	-3	2
F16	2	2	2	2	2	2	2	2	2	2	-3	2

Table B14 - Troed-y-Rhiw - consented noise limits and analysis (L_{A90}, dB).

Property/period	Standardised 10 m Wind Speed (m/s)						
	4	5	6	7	8	9	10
PYC consented noise limit – day-time	44	45	45	45	45	45	45
PYC consented noise limit – night-time	45	45	45	45	45	45	45
Prediction: PYC	32	37	42	43	43	43	43
Prediction: Ffynnon Oer	26	29	33	36	38	39	40
Prediction: Ffynnon Oer + PYC	33	38	42	44	44	45	45
Predictions: Proposed Development	23	27	31	31	31	31	31

Annex C – Background Noise and Noise Limits

Figure C1 Chart of background noise levels against wind speeds, the best fit curve to the data, the derived noise limit curve for Fforch-dwm Farm during quiet day time periods. Predicted immission noise levels are also shown for the Proposed Development and the other wind farms considered and the cumulative total.

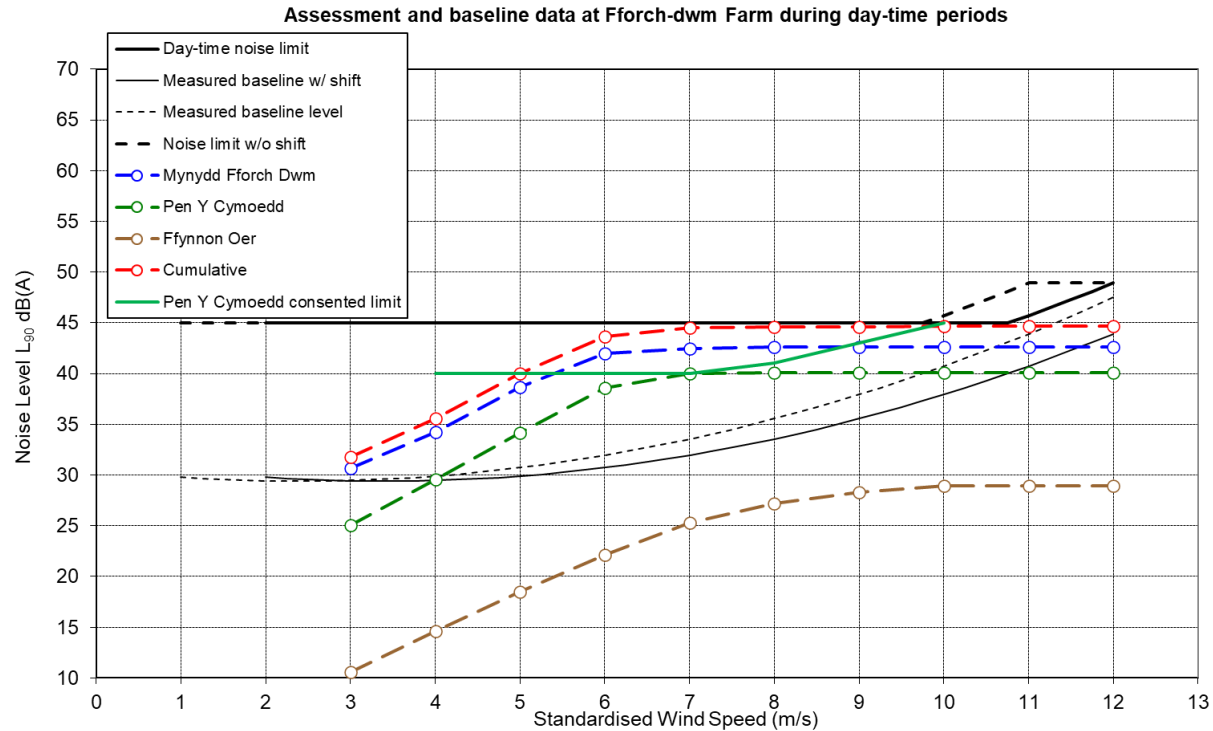


Figure C2 Chart of background noise levels against wind speeds, the best fit curve to the data, the derived noise limit curve for Fforch-dwm Farm during night-time periods. Predicted immission noise levels are also shown for the Proposed Development and the other wind farms considered and the cumulative total.

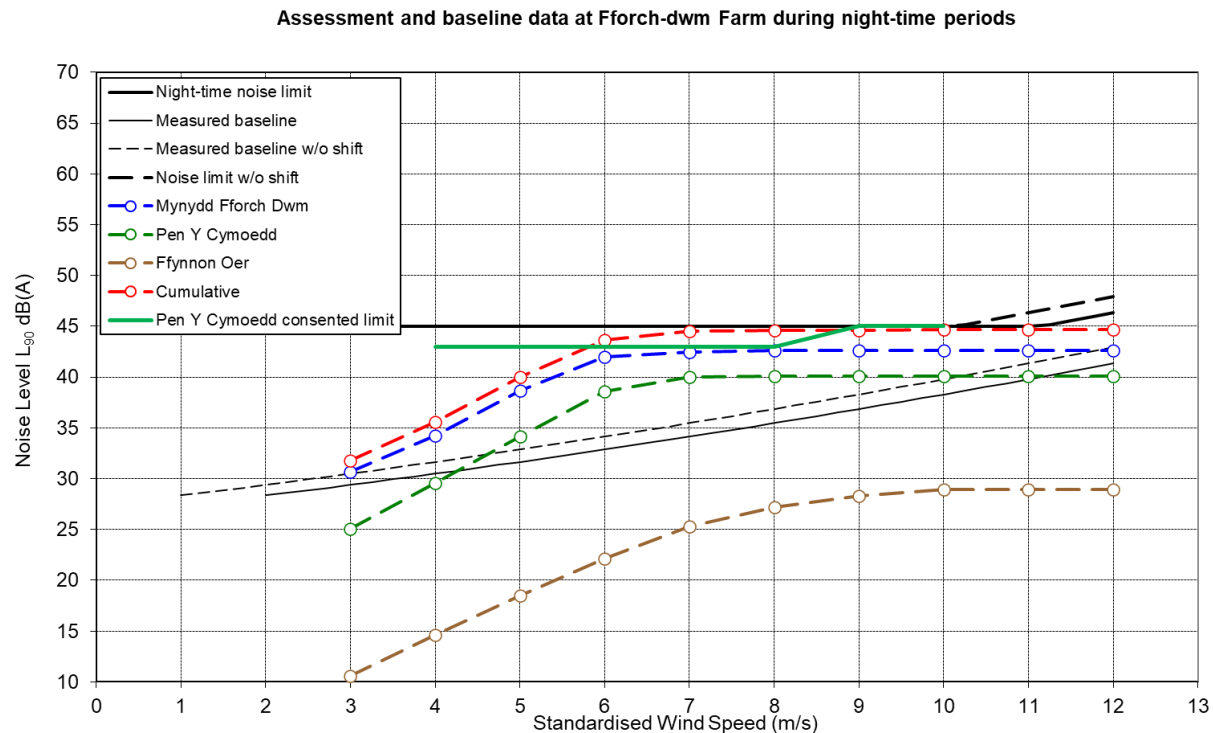


Figure C3 Chart of background noise levels against wind speeds, the best fit curve to the data, the derived noise limit curve for Gyfylchi Farm during day-time periods. Predicted immission noise levels at Tyn-ton are also shown for the Proposed Development and the other wind farms considered and the cumulative total.

Assessment at Tyn-ton (baseline data from Gyfylchi Farm during day-time periods)

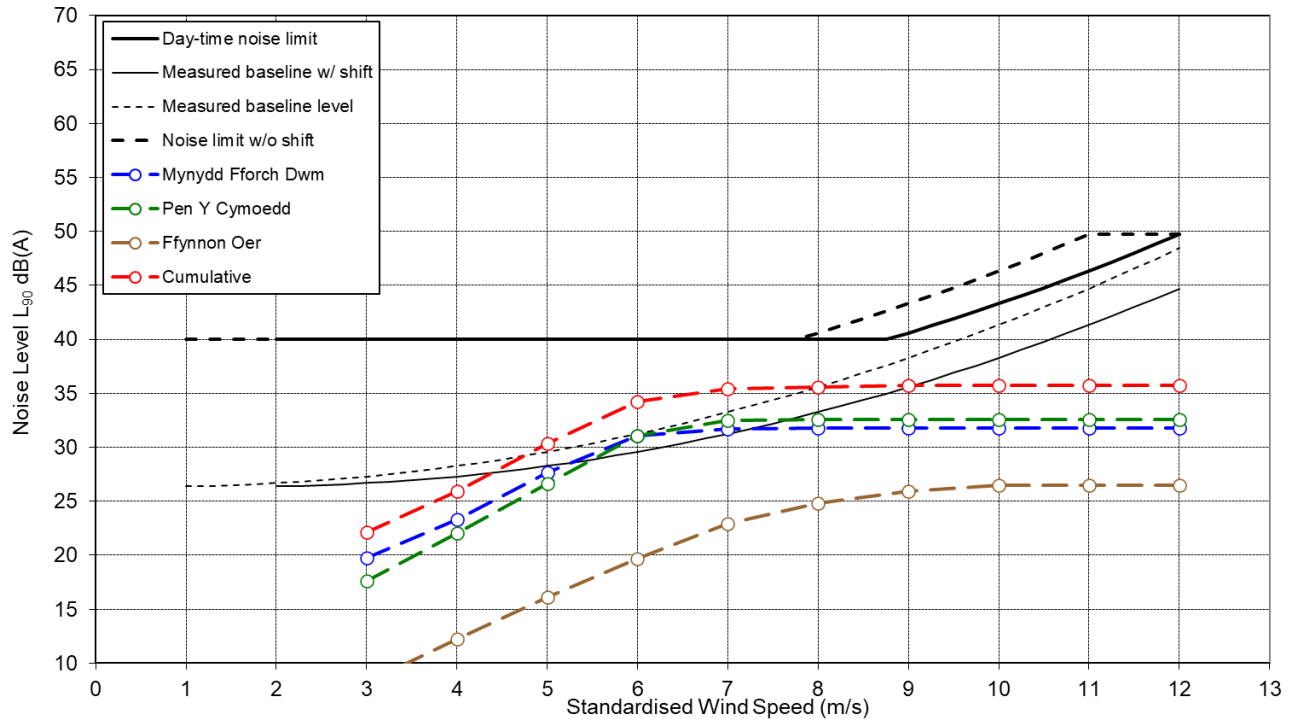


Figure C4 Chart of background noise levels against wind speeds, the best fit curve to the data, the derived noise limit curve for Gyfylchi Farm during night time periods. Predicted immission noise levels at Tyn-ton are also shown for the Proposed Development and the other wind farms considered and the cumulative total.

Assessment at Tyn-ton (baseline data from Gyfylchi Farm during night-time periods)

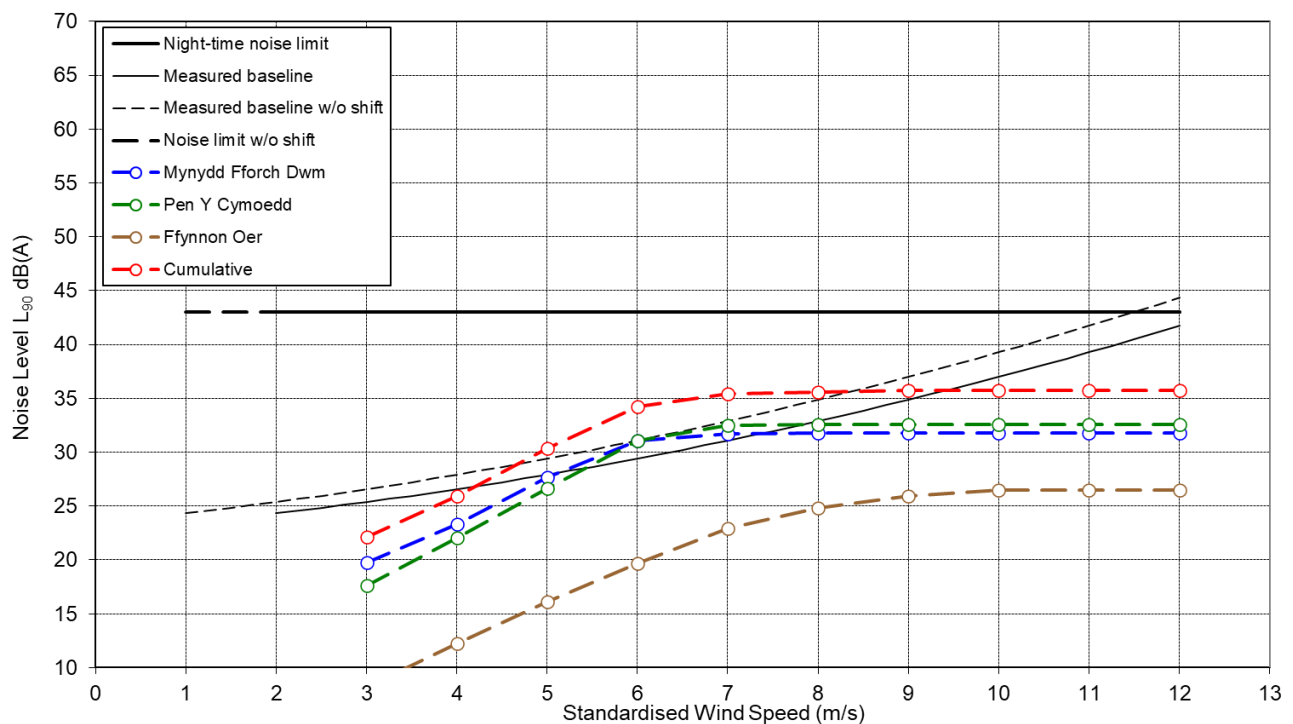


Figure C5 Chart of background noise levels against wind speeds, the best fit curve to the data, the derived noise limit curve for Glenview, Railway Terrace during day-time periods. Predicted immission noise levels at Pelenna House are also shown for the Proposed Development and the other wind farms considered and the cumulative total.

Assessment at Pelenna House (baseline data from Glenview, Railway Terrace during day-time periods)

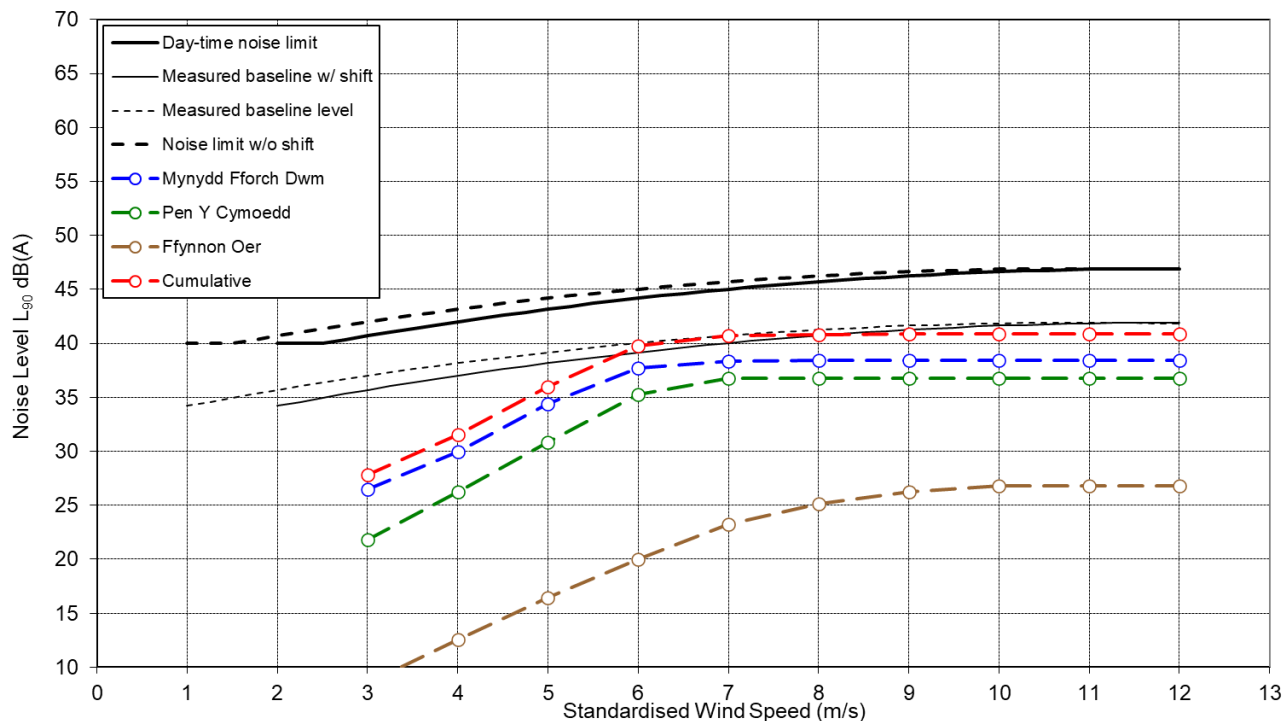


Figure C6 Chart of background noise levels against wind speeds, the best fit curve to the data, the derived noise limit curve for Glenview, Railway Terrace during night-time periods. Predicted immission noise levels at Pelenna House are also shown for the Proposed Development and the other wind farms considered and the cumulative total.

Assessment at Pelenna House (baseline data from Glenview, Railway Terrace during night-time periods)

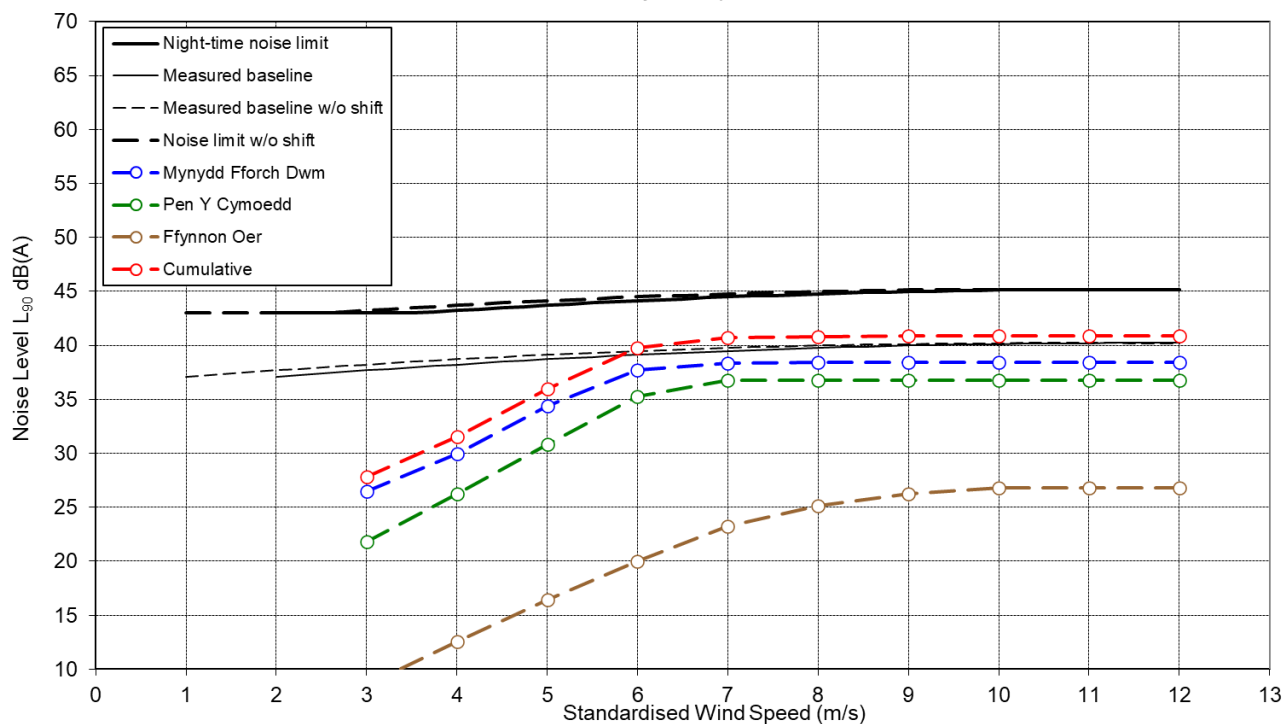


Figure C7 Chart of background noise levels against wind speeds, the best fit curve to the data, the derived noise limit curve for Uwch-y-Glyn during quiet day-time periods. Predicted immission noise levels at Blaenafon Farm are also shown for the Proposed Development and the other wind farms considered and the cumulative total.

Assessment at Blaenafon Farm (baseline data from Uwch-y-Glyn (Tonmawr) during day-time periods)

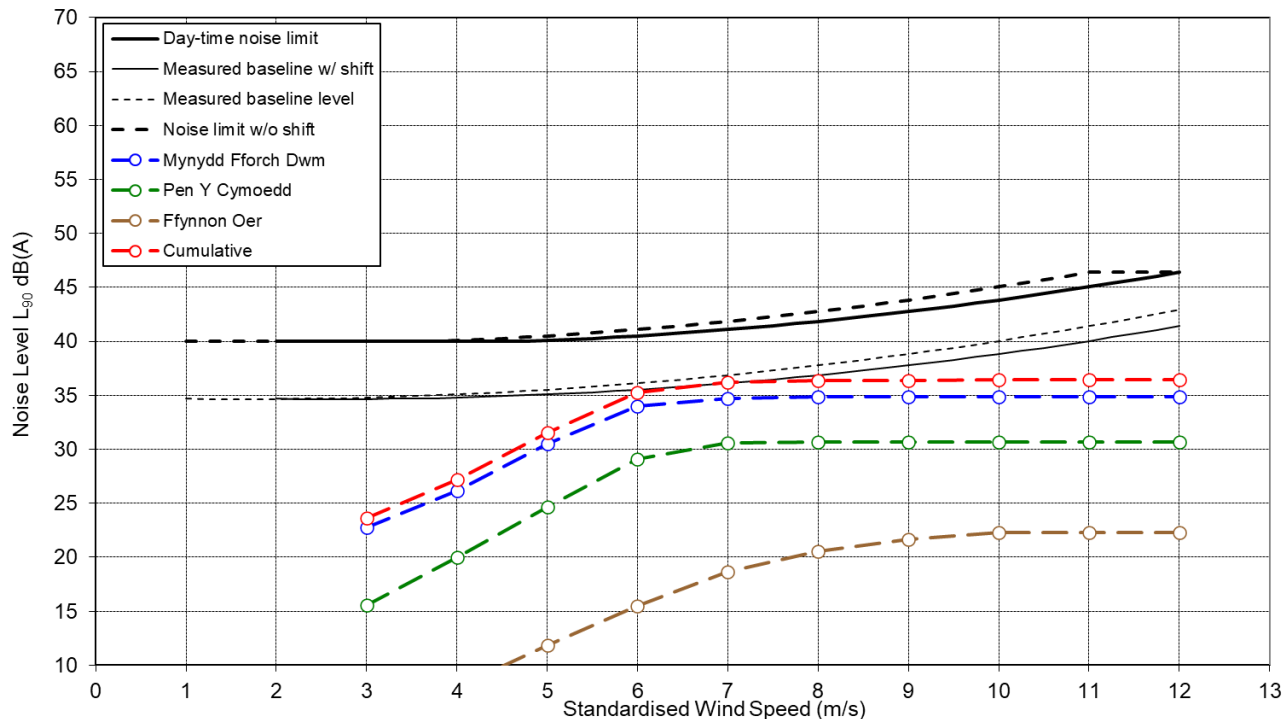
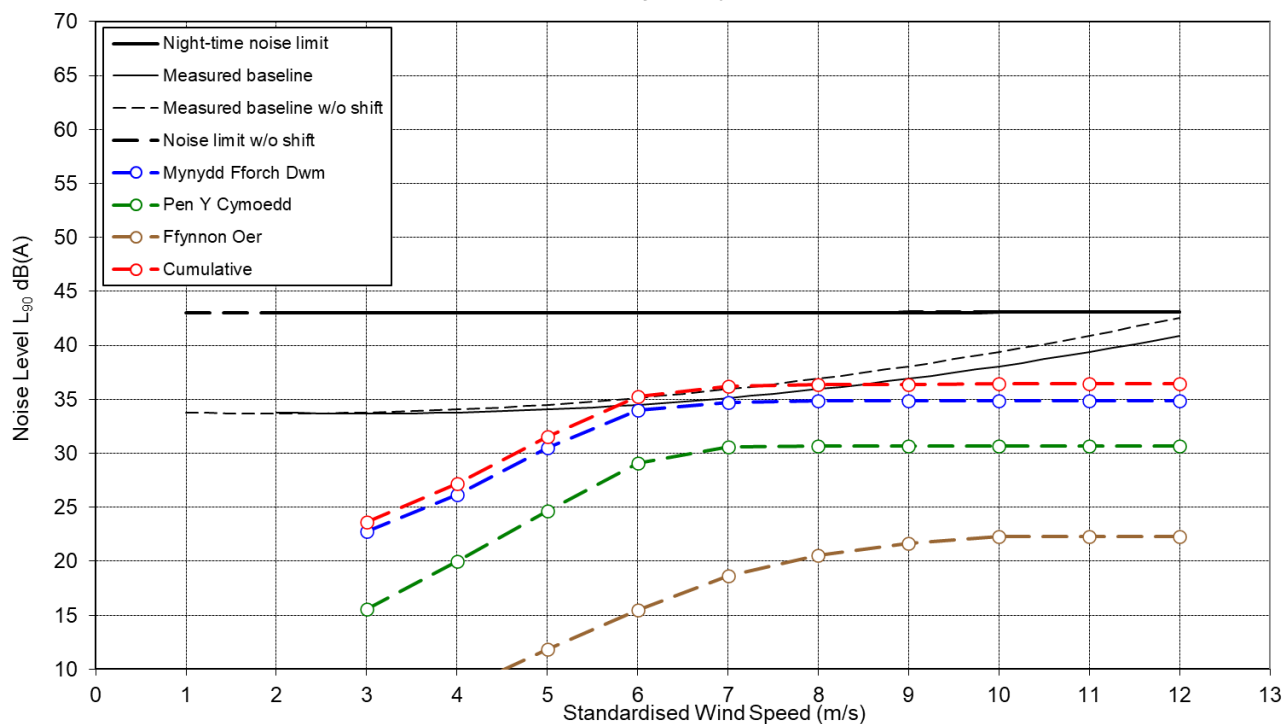


Figure C8 Chart of background noise levels against wind speeds, the best fit curve to the data, the derived noise limit curve for Uwch-y-Glyn during night-time periods. Predicted immission noise levels at Blaenafon Farm are also shown for the Proposed Development and the other wind farms considered and the cumulative total.

Assessment at Blaenafon Farm (baseline data from Uwch-y-Glyn (Tonmawr) during night-time periods)





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