11 ACOUSTIC

11.1 Introduction

11.1.1 This chapter contains an assessment of the acoustic impact of the proposed Mynydd Maen Wind Farm (hereafter referred to as the proposed wind farm). The chapter assesses wind farm operational noise and discusses construction noise at the nearest residential properties.

11.1.2 This chapter is supported by the following Technical Appendices:

- Technical Appendix 11.1 – Renewable Energy Systems (RES) Publications
- Technical Appendix 11.2 – Issues Scoped Out
- Technical Appendix 11.3 – Background Noise Survey Locations
- Technical Appendix 11.4 – Instrumentation Records
- Technical Appendix 11.5 – Derived Background Noise Levels & Limits
- Technical Appendix 11.6 – Curtailment Strategies
- Technical Appendix 11.7 – Assessment Charts
- Technical Appendix 11.8 – Draft Planning Condition

11.1.3 The relevant Figures and Technical Appendices are referenced in the text where necessary.

11.1.4 Noise can affect the environment in terms of the quality of life enjoyed by individuals and communities, both in terms of the construction and operation of a particular development and is, therefore, a material consideration in the determination of planning applications.

Statement of Authority

11.1.5 This assessment has been undertaken by RES, with three in-house Members of the Institute of Acoustics (MIOA) involved in its production. RES has undertaken acoustic impact assessments in every single one of its UK wind farm development applications since 2000 and has also reported to several local planning authorities on operational wind energy projects, and various other renewable development, including taking measurements on newly constructed wind farms to ensure compliance with planning conditions, investigate sources of complaint and determine relevant remedial action where necessary.

11.1.6 Additionally, RES has been project co-ordinator for several Joule projects (DGXII European Commission funded projects in the field of Research and Technological Development in non-nuclear energy); led European research into wind turbine noise; was involved in producing the guideline 'The Assessment and Rating of Noise from Wind Farms' ETSU for the DTI in 1996; acted as peer reviewer for the 'Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise' (IOA GPG), and contributed to works conducted via RenewableUK work on Amplitude Modulation (AM).

11.1.7 A list of relevant publications is provided in **Technical Appendix 11.1: Renewable Energy Systems (RES) Publications**.

Operational Noise

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

11.1.9 The main focus of the assessment of operational noise presented here is the aerodynamic noise generated by the turbine blades passing through the air, which is generally broadband in nature. Mechanical noise, which can be tonal in nature and can sometimes be generated from the equipment installed in the hub of wind turbines or result from blade defects, is also discussed. However, this is considered less relevant to modern wind turbines.

11.1.10 Implicitly incorporated within this assessment is the normal character of the noise associated with wind turbines (commonly referred to as 'blade swish') and consideration of a range of noise frequencies, including low frequencies.

11.1.11 In the context of other sources of environmental noise, the noise levels produced by wind turbines are generally low and have particular dependence upon wind speed. The combination of these two factors implies that, in many instances a certain degree of turbine noise masking would often be provided by other environmental noise sources including wind induced noise, such as that generated by trees and foliage, at ground level.

Construction Noise & Vibration

11.1.12 Noise and vibration associated with the construction of wind turbines can arise from activities relating to the introduction of turbine foundations at the site; the introduction of access tracks; the use of cranes to install the towers, hubs and blades; the introduction of ancillary equipment and cabling; upgrades to existing access routes; blasting and mining at small quarries known as 'borrow pits', and from construction traffic travelling along access routes and the local road network.

11.1.13 The sources of construction noise and vibration, which are temporary, would vary both in location and duration as the different elements of the proposed wind farm are constructed and would arise primarily through the operation of large items of plant.

11.2 Scope of Assessment

11.2.1 This section provides the generalised scope of the assessment and the associated rationale. The specific details and particulars of the scope, as discussed with representatives of the relevant Local Planning Authority (LPA), is detailed in Section 11.4.

Operational Noise

11.2.2 The noise which may be generated by the operation of the proposed wind farm in isolation, and cumulatively with other potential development in the area, has been assessed in full according to documentation referenced within relevant planning policy on noise.

11.2.3 The assessment incorporates the assessment of operational noise for a range of frequencies most relevant to turbine operation, including that generated at relatively low frequencies. A specific and targeted assessment of low frequency noise (in the frequency range of approximately 20 to 200 Hz) and infrasound (less than 20 Hz) has not been undertaken as this is not required by current planning policy and is considered unjustified based on various research and relevant documentation on these topics.

11.2.4 The assessment also accounts for the inherent character of noise generated by turbine blades as they pass through the air known as 'blade swish' or amplitude modulation (AM); factors in the effects of wind shear (i.e. the rate of change in wind speed with height above ground level) according to best practice in this regard; accounts for relevant noise propagation effects in terms of topographical valley and shielding considerations and is based on information provided by the manufacturer for a candidate turbine considered for the purposes of this assessment.

11.2.5 A discussion of relevant research and documentation relating to low frequency noise; infrasound; sleep disturbance; vibration; amplitude modulation; 'wind turbine syndrome'; and health effects associated with the operation of wind turbines in general is provided in **Technical Appendix 11.2: Issues Scoped Out**. These topics have not been assessed in any further detail herein other than that required under current planning guidance in this regard.

Construction Noise & Vibration

11.2.6 The construction of turbines, ancillary electrical equipment, compounds and the corresponding access tracks typically occurs at very large distances from neighbouring residences. The resultant noise and vibration, which would be temporary in nature, is only very rarely cause for concern in terms of the potential for disturbing the inhabitants of neighbouring residences. Whilst the noise associated with the construction of these aspects

may well be audible to people residing in the area, the levels would be below established noise limits and planning requirements in this respect. Nevertheless, typical mitigation measures, including the use of 'best practicable means' would be incorporated into the construction practices for the proposed wind farm with a view to reducing noise levels where possible and practical. As a result, this aspect is only discussed in generalised terms with reference to standard noise limiting requirements; typical working practices; hours of work, and standard mitigation measures in this respect. A detailed assessment has not been undertaken.

11.2.7 Construction relating to the provision of access to the site, including the upgrade of local roads and their use thereof, may well occur at locations near to residences. As a result, and in instances where this is likely to occur, consideration of enhanced mitigation measures which would be reasonably possible to implement, have been discussed. In any event, typical noise limiting requirements would apply and the contractor undertaking the works would be responsible for potential issues and taking appropriate and reasonable steps to address these should they occur. As a result, this aspect is also discussed in generalised terms and a detailed assessment has not been undertaken as this would require a detailed construction plan to provide confidence in the results, which is not available at this time. However, certain details as to construction practices would be provided within a Construction Environmental Management Plan (CEMP), with reference to potential noise and vibration impacts, where necessary.

11.2.8 Noise and vibration associated with the movement of additional vehicles, including heavy goods vehicles (HGVs) along local roads and access routes may well be noticeable to residents adjacent to these. However, this would essentially only result in a minor increase in the average noise levels from existing roads, with the most noticeable noise and perceptible vibration effects resulting from the sporadic and increased number of HGV pass-bys at residences along the access routes, with resulting levels for individual events being similar to that created by existing HGV movements.

11.2.9 In order to release materials at proposed 'borrow-pit' locations, the use of specifically designed explosives may be used, this is also known as blasting. The resultant noise, vibration and air overpressure from blasting cannot be reliably predicted. However, these aspects may well be perceptible to neighbouring residents. The vibration generated by each blast would be well below levels that would be expected to cause damage to the nearest housing and/or structures nearby. As a result, the impacts resulting from blasting is not considered in any detail other than the provision of discussion as to the steps to limit any resulting impact through appropriate blast design and best practice, which also involves keeping residents informed as to planning blasting activities.

11.3 Legislative Framework & Guidance

Future Wales – The National Plan 2040

11.3.1 The overall national development framework which sets out the direction for development in Wales to 2040 is provided within the document Future Wales – The National Plan 2040 [1]. The documents states that "Planning Policy Wales [PPW] contains the planning policy framework for addressing air quality, soundscape and noise" and provides two policies that specifically relate to renewable and low carbon energy development. Policies 17 and 18 are interrelated, detailing renewable and low carbon energy development in general and schemes qualifying as Developments of National Significance (DNS) respectively, stating that these types of development, including re-powering, would be permitted provided that various matters are considered acceptable including that "there are no unacceptable adverse impacts by way of shadow flicker, noise, reflected light, air quality or electromagnetic disturbance". Policy 18 also states that the "… cumulative impacts of existing and consented renewable energy schemes should also be considered".

Planning Policy Wales (PPW) – Edition 11

11.3.2 The introduction to Planning Policy Wales (PPW) – Edition 11 [2] states that the document "…sets out the land use planning policies of the Welsh Government. It is supplemented by a series of Technical Advice Notes (TANs), Welsh Government Circulars, and policy clarification

letters, which together with PPW provide the national planning policy framework for Wales. PPW, the TANs, MTANs and policy clarification letters comprise national planning policy".

11.3.3 Noise is referenced throughout the document and in various contexts including transport; commercial operations; entertainment; mining; industrial facilities; sensitive development; energy, and renewable development amongst others. The general focus is on reducing or minimising the effects of noise pollution wherever possible. Specifically in respect of renewable and low carbon energy development, the document states that the "… construction, operation, decommissioning, remediation and aftercare of proposals, should take into account the need to minimise impacts on local communities, such as from noise and air pollution, to safeguard quality of life for existing and future generations; cumulative impact; and the capacity of, and effects on the transportation network" amongst other points.

11.3.4 The PPW refers to Noise Action Plans (NAPs) which aim to "… prevent and reduce environmental noise where necessary and preserve environmental noise quality where it is good" and practice guidance (PG) which highlights "… the planning implications of a wide variety of renewable energy technologies".

11.3.5 The PPW document also states that, in some circumstances, it will be necessary for a technical assessment to be provided to support planning applications for certain development, referencing ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms' and the associated Good Practice Guide, as published by the Institute of Acoustics (IOA GPG), in relation to energy producing development.

Noise and Soundscape Plan for Wales 2023 to 2028

11.3.6 The Noise and Soundscape Action Plan for Wales 2023-2028 [3] defines environmental noise and/or noise pollution as sound "… that is judged or perceived to be unwanted or harmful". The plan references the current planning guidance on noise from wind farms (i.e. ETSU-R-97 and the associated IOA GPG discussed above) and provides further reference to a recent review of current practice in this respect.

11.3.7 The review referred to above was released in October 2022 [4] and makes several recommendations including that current guidance in respect of wind farm noise is updated and/or reviewed to take into account the current evidence base on noise effects; that further studies on sound exposure be undertaken; further evidence on amplitude modulation (AM) is gathered; clarification and evidence in respect of residential financial involvement is obtained; the means by which tonality is assessed is reviewed and/or updated; and that further guidance or statements regarding cumulative impacts, instrumentation, propagation, policy balance and infrasound are provided.

Practice Guidance - Planning Implications of Renewable and Low Carbon Energy

11.3.8 The document Practice Guidance (PG) - Planning Implications of Renewable and Low Carbon Energy [5] is "… a tool to support Local Planning Authorities (LPAs) in dealing with applications for renewable and low carbon energy development" and highlights the effects and typical planning considerations for a variety of these type of developments. The document considers wind energy development in Section 3 and provides a description of the noise sources associated with turbine operation, referring to ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms' as providing the basis for which operational noise limits for wind farms are set. The guidance also references BS 5228 'Noise and Vibration Control on Construction and Open Sites' and BS 8233 'Sound Insulation and Noise Reductions for Buildings' when considering noise associated with the construction of wind farm developments.

Designing for Renewable Energy in Wales

11.3.9 The Welsh Government released Designing for Renewable Energy in Wales [6] in November 2023 which refers to Policies 17 and 18 of Future Wales – The National Plan. In respect of operational noise from wind farm developments, the draft guidance states that "Irrespective of location or scale, the design and micro-siting of wind turbines must seek to minimise their noise impact, particularly where turbines would be near homes and tourism receptors. The current UK wind turbine noise assessment guidance for residential receptors is set out in ETSU-R-97, a Good Practice Guide on the application of ETSU-R-97, and Supplementary Guidance Notes. The Welsh Government has endorsed the use of this guidance in Wales. A review of

noise guidance for on-shore wind turbines has been undertaken and any changes to UK guidance arising from this review will be considered by the Welsh Government".

Technical Advice Note 11 (TAN 11) - Noise

11.3.10 Technical Advice Note 11: Noise (TAN 11) [7] "… provides advice on how the planning system can be used to minimise the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business." The guidance refers to detailed guidance on noise from wind turbines being contained in Technical Advice Note 8: Planning for Renewable Energy.

11.3.11 In respect of construction noise, TAN 11 states that "Detailed guidance on assessing noise from construction sites can be found in BS 5228, parts 1-4. In particular, Part 1: 1984, 'Code of practice for basic information and procedures for noise control' describes a method for predicting noise from construction sites as well as giving general advice". However, as noted within CL-01-15 Updates to TAN 11 Noise - Noise Action Plan (2013-18) Commitments [8], this standard has updated since the adoption of TAN 11 and the newer version has been referred to as a result.

Technical Advice Note 8 (TAN 8) - Planning for Renewable Energy

11.3.12 In relation to noise from wind farms Technical Advice Note 8: Planning for Renewable Energy (TAN 8) [9] states that "The report 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97), describes a framework for the measurement of wind farm noise and gives indicative noise levels calculated to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or planning authorities. The report presents the findings of a cross-interest Noise Working Group and makes a series of recommendations that can be regarded as relevant guidance on good practice". When Future Wales - The National Plan 2040 was published, in February 2021, TAN 8 was revoked.

Operational Noise

The Assessment & Rating of Noise from Wind Farms (ETSU-R-97)

11.3.13 The operational noise assessment methodology described in ETSU-R-97 [10] was developed by a working group comprised of a cross section of interested persons including Environmental Health Officers (EHOs), wind farm operators and independent acoustic experts amongst others.

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

11.3.15 The basic aim of ETSU-R-97, in arriving at the recommendations contained within the report, is the intention to provide "Indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities.".

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

A Good Practice Guide to the Assessment & Rating of Noise from Wind Farms (IOA GPG)

11.3.17 A Good Practice Guide (IOA GPG) on the application of ETSU-R-97 for the assessment and rating of wind turbine noise [11], issued by the IOA in May 2013 and endorsed by the Welsh

Government along with the governments in England, Scotland and the Northern Ireland Executive, provides guidance on all aspects of the use of ETSU-R-97 and reaffirms the recommendations of an IOA Acoustics Bulletin [12] article in relation to issues not made explicit by, or outside the scope of ETSU-R-97, including propagation modelling and wind shear. The document also includes further information regarding cumulative noise impacts, compliance measurements and other relevant topics.

11.3.18 Supplementary guidance notes were published by the Institute of Acoustics (IOA) in July and September 2014, and these provide further details on specific areas of the IOA GPG. The assessment presented herein adopts these recommendations and those within the associated Supplementary Guidance Notes (SGN).

BS 8233 Guidance on Sound Insulation and Noise Reduction for Buildings

11.3.19 BS 8233:2014 'Guidance on sound insulation and noise reduction for buildings' [13] "draws on the results of research and experience to provide information on the design of buildings that have internal acoustic environments appropriate to their functions. It deals with control of noise from outside the building, noise from plant and services within it, and room acoustics for non-critical situations". The standard provides recommended average noise levels for internal spaces such as living rooms and bedrooms. The standard also provides a section on noise from wind farms, recommending the use of ETSU-R-97 and the IOA GPG for assessment purposes and states that "A particular feature of aerodynamic noise, which is often cited as an adverse feature of medium to large wind turbines, is that of amplitude modulation (AM), which is the modulation or rhythmic swish. Excess AM can sometimes occur. However, it cannot be predicted at the planning stage with the current state of the art".

Construction Noise & Vibration

BS 5228-1 Code of Practice for Noise and Vibration Control on Construction and Open Sites - Part 1: Noise

11.3.20 BS 5228-1:2009 'Code of practice for noise and vibration control on construction and open sites - Part 1: Noise' [14], this has been identified as being the appropriate source of guidance on appropriate methods for minimising noise from construction activities and is adopted herein. This document supersedes the 1984 version referred to within TAN 11. The document provides guidance on construction noise limits, noise modelling techniques and best practicable measures for the reduction of noise generated during construction activities including overpressure from blasting at borrow pits.

BS 5228-2 Code of Practice for Noise and Vibration Control on Construction and Open Sites - Part 2: Vibration

11.3.21 BS 5228-2:2009 'Code of practice for noise and vibration control on construction and open sites - Part 2: Vibration' [15], provides a method for predicting levels of vibration. The document provides guidance on construction vibration limits, vibration modelling techniques and best practicable measures for the reduction of vibration generated during construction activities including blasting at borrow pits.

BS 6472-2 Guide to Evaluation of Human Exposure to Vibration in Buildings - Part 2: Blast-induced Vibration

11.3.22 BS 6472-2:2008 'Guide to evaluation of human exposure to vibration in buildings - Part 2: Blast-induced vibration' [16] provides criteria for satisfactory magnitudes of vibration at nearby residential properties to ensure compliance with respect to human response.

The Control of Pollution Act (CoPA)

11.3.23 The Control of Pollution Act (CoPA) 1974 [17] provides information as to the need for ensuring that the 'best practicable means' are employed to minimise noise.

11.4 Consultation

11.4.1 In addition to the EIA Scoping Direction, details of the consultation undertaken, informing the detailed scope of works shown here, are outlined in **Table 11.1**.

Table 11.1 Acoustic Assessment Consultation

Consultee(s)	Date	Nature & Purpose of Consultation
Caerphilly and Torfaen County Borough Councils	15/03/2022	Planned Acoustic Assessment at the Proposed Mynydd Maen Wind Farm (04412-2960766 issue 1) sent to the Environmental Health Departments to review. Report details proposed assessment methodology along with suggested background noise survey locations.
Torfaen County Borough Council	04/04/2022	EHO (Environmental Health Officer) requests that RES submit a report via the planning process. General wind farm noise guidance provided. Assessments should be in line with ETSU-R-97 and the IOA GPG. Impact of turbine noise on amenity of dog walkers and ramblers should also be considered.
Caerphilly County Borough Council	08/04/2022	EHO requests that additional survey locations including one to enable assessment of impact on public recreational areas.
Caerphilly County Borough Council	12/04/2022	Response to EHO providing justification for selected survey location and requesting guidance on how the impact on public recreational areas should be assessed.
Caerphilly County Borough Council	29/04/2022	EHO response stating that the Noise and Soundscape Action Plan for Wales 2018-2023, WHO Environmental Noise Guidelines for the European Region 2018 and Planning Policy Wales can be referred to in order to assess the impact on public recreational land.
Torfaen County Borough Council	20/07/2022	General wind farm noise guidance again provided by EHO.
Torfaen County Borough Council	02/09/2022	The EHO provided a response saying they have no comments on proposed survey locations, including the use of H14 as an alternative for H15, where the resident could not be contacted.
Caerphilly and Torfaen County Borough Councils	07/10/2022	Invitation sent to EHO to attend the installation of equipment for conducting the background noise survey.
Torfaen County Borough Council	10/10/2022	The EHO accepted the invitation to attend the installation of equipment for conducting the background noise survey. There were various subsequent emails discussing the practical arrangements for attending the survey.
Torfaen County Borough Council	11/10/2022	The EHO requested confirmation that cumulative operational impacts due to other proposed wind farms will be considered as part of the documentation supporting the planning application for the proposed development, including the proposed Trecelyn Wind Farm.

Consultee(s)	Date	Nature & Purpose of Consultation
Caerphilly County Borough Council	12/10/2022	The EHO (and 2 additional colleagues from Environmental Health) accepted the invitation to attend the installation of equipment for conducting the background noise survey. There were various subsequent communications discussing the practical arrangements thereof.
Torfaen County Borough Council	12/10/2022	Confirmation given to the EHO that cumulative operational noise impacts will be considered. A list of the cumulative wind farms was provided to the EHO.
Torfaen County Borough Council	17/10/2022	Email stating that EHO is not able to attend the installation of equipment for conducting the background noise survey at H6, H14, H25 and H28.
Caerphilly County Borough Council	17/10/2022	EHO (and in addition 2 colleagues from Environmental Health) attended the installation of equipment for conducting the background noise survey at property H19 and agreed the location of the equipment.
Caerphilly County Borough Council	4/11/2022	Noise Survey Locations for the Acoustic Assessment of the Proposed Mynydd Maen Wind Farm (04412-4816187 issue 1) sent to the EHO. This document has details of the background noise survey locations where the equipment was installed for reference.
Torfaen County Borough Council	4/11/2022	Noise Survey Locations for the Acoustic Assessment of the Proposed Mynydd Maen Wind Farm (04412-4816187 issue 1) provided to the EHO. This document has details of the background noise survey locations where the equipment was installed for reference. No comments from EHO on survey locations detailed in report. Guidance sought from EHO on the requirements for a background noise survey location in the village called Pantygasseg, as it was not possible to access the originally proposed location of H28. There were various subsequent emails discussing a viable alternative location.
Torfaen County Borough Council	15/11/2022	The EHO confirmed the proposed alternative location of H29 in the village of Pantygasseg is acceptable as a background noise survey location instead of H28. There were various subsequent emails on practical arrangements for the survey at this location. The EHO accepted the invitation to attend the installation of equipment for conducting the background noise survey at this location.
Torfaen County Borough Council	29/11/2022	The EHO attended the installation of equipment for conducting the background noise survey at property H29 and agreed the location of the equipment.

Consultee(s)	Date	Nature & Purpose of Consultation
Caerphilly and Torfaen County Borough Councils	27/07/2023	Updated Noise Survey Locations for the Acoustic Assessment of the Proposed Mynydd Maen Wind Farm (04412-4816187 issue 2) sent to the EHOs of the two borough councils. This document provides updated details of the background noise survey locations (including H29) where the equipment was installed for reference.

11.4.2 The impact of wind turbine noise on ramblers and dog walkers is not considered within the current Noise and Soundscape Action Plan for Wales, nor any other guidance. The response to the proposed wind farm, by people using the various public rights of way crossing the development site in terms of operational noise impacts, will be entirely subjective. However, an indication of the varying expected levels of operational sound generated by the Proposed Development on the rights of way crossing the Site are shown in **Figure 11.1** and **Figure 11.2**.

11.4.3 There are numerous existing wind farms in the United Kingdom where similar operational noise levels are expected along walking/access routes for which no disbenefits have been reported. Furthermore, the existence of certain wind farm sites has sometimes increased the use of certain routes. The operational noise generated by the turbines onsite will be at a level for which it would be easy to hold a conversation, even when positioned right next to any particular turbine. Furthermore, there is no evidence these typical levels of onsite operational turbine noise would result in any potential health impacts. The sensitivity of the users of public rights of way are therefore considered low and the resultant magnitude of operational effects is considered low, resulting in minor overall impacts and an overall operational effect that is not significant. This aspect has not been considered further as a result.

11.4.4 During construction and decommissioning of the Proposed Development occasional temporary sound and vibration generated during the various phases may well be perceptible to users of the rights of way. The more direct impacts will be mitigated via the re-routing or temporary closure of footpaths where existing routes may be obstructed by ongoing construction/decommissioning works and/or health and safety issues may exist. Acoustic factors will also be mitigated due to the increased separation from users of the public rights of way as a result of re-routing. All best practice will be followed in terms of health & safety and environmental measures to minimise the impact. Similarly to the above, a low sensitivity is attached to users of the rights of way, the magnitude of impact is considered low (provided that suitable mitigation measures are put in place) and considering that the works are temporary, the overall impact is considered not significant.

11.5 Methodology

Operational Noise

11.5.1 The full operational noise assessment methodology prescribed within ETSU-R-97 requires that measurements of the existing background/baseline noise levels are undertaken at a number of locations representative of residences neighbouring a proposed wind farm. This information is correlated with the wind speed simultaneously experienced at the proposed wind farm, allowing for the determination of average background noise levels over a range of wind speed conditions. This then allows for appropriate daytime and night-time criteria to be derived in relation to the average measured background noise levels over the same conditions.

11.5.2 ETSU-R-97 makes it clear that background/baseline noise levels should not be influenced by the presence of existing turbine noise and that the derived limits, in terms of planning acceptability, should apply to the expected noise levels generated by the combined operation of the proposed wind farm and other existing, planned, or consented development in the area, in instances where these cumulative impacts are relevant.

11.5.3 The expected turbine noise levels resulting from the proposed wind farm (including for other cumulative development), at the nearest residential properties, are predicted for a range of wind speeds using a sound propagation model that incorporates the locations of the wind turbines, the intervening terrain and the likely noise emission characteristics of a candidate turbine which could be installed at the site(s).

11.5.4 The resultant predicted turbine noise levels and derived daytime and night-time noise criteria are compared to determine whether the site meets the relevant operational noise limits required by planning policy.

Operational Baseline Conditions

11.5.5 The ETSU-R-97 and IOA GPG methodology requires the comparison of predicted noise levels due to turbine emissions (which vary with hub height wind speed) with noise limits based upon the noise levels already existing under those same conditions (i.e. the baseline). This is similar, in principle, to the assessment of other noise generating facilities which are required to be assessed according to BS 4142 'Methods for rating and assessing industrial and commercial sound' [18] for which ETSU-R-97 identifies the 1990 version [19] as forming the basis of its recommendations.

11.5.6 Since background noise levels in rural environments often vary with induced noise generated by the wind passing through trees and foliage surrounding dwellings and that wind turbine noise emissions also vary with wind speed, it is important that this context is considered when conducting reference measurements.

11.5.7 Thus, the assessment of background noise levels at potentially sensitive residential properties requires the measurement of not only noise levels, but concurrent wind conditions, covering a representative range of wind speeds. These wind measurements are made at the site rather than at the residential properties since it is this wind speed that would subsequently govern the wind farm's sound generation. Occasionally, the residential properties themselves will be sheltered from the wind and may consequently have relatively low background sound levels, even at high wind speeds.

11.5.8 To establish the baseline conditions, sound level meters and associated apparatus are set-up to record the required acoustic information at a selection of the nearest residential properties geographically spread around the site, as agreed with Environmental Health Officers (EHO) representing the LPA, which are likely to be representative of other residential properties in the locale.

11.5.9 In order to the establish the background/baseline noise levels considered representative of properties neighbouring the proposed wind farm the measurement data is separated in to two sets, as specified by ETSU-R-97 and shown in **Table 11.2**.

Table 11.2 Definition of Quiet Daytime & Night-time Periods

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

11.5.10 Any data affected by the pattering of rainfall at the measurement location and on the measurement equipment itself, which can result in increased measured noise levels, is systematically removed from the acoustic data set. To facilitate this, a tipping bucket rain gauge is deployed at the site to record 10-minute rainfall data and identify potentially affected noise data. Both the 10-minute period containing the bucket tip and the preceding 10-minute period are removed from the dataset as recommended in the IOA GPG. This is to account for the time it takes for the tipping bucket to fill.

11.5.11 Periods of measured background noise data thought to be affected by extraneous (i.e. non-typical, noise sources) are identified and removed from the data set. Whilst some 'extraneous' data may actually be real, this tends to bias trend lines upwards, so is removed as a conservative measure.

11.5.12 In practice, the above means close inspection of the measured background noise levels, comparison with concurrent data measured at nearby locations and consideration of both directional and temporal variation in the measured noise levels. This may include filtering of data to remove any data affected by dawn chorus, the presence of boiler flues, increased traffic movements during certain times and obvious effects correlated to the wind direction

experienced during the survey with due regard to the location of the property relative to the wind farm site.

Operational Noise Impact Criteria

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

11.5.14 Whilst ETSU-R-97 presents a comprehensive and detailed assessment methodology for wind farm noise, it also provides a simplified methodology, stating that "if the noise is limited to an $L_{A90,10min}$ of 35 dB(A) up to wind speeds of 10 m/s at 10 m height, then these conditions alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary".

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

Table 11.3 Permissible Noise Criteria

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

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

11.5.17 Further to the above, the absolute lower noise limits may be increased up to 45 dB(A) for both daytime and night-time periods if the occupant of a property has a financial involvement in the proposed wind farm. However, whilst some of the nearby properties may qualify for such an increase, these limits have not been adopted in the assessment as a conservative measure.

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

11.5.19 It is important to note that, since reactions to noise are subjective, it is not possible to guarantee that a given development would not result in any adverse comment regarding noise as the response to any given noise will vary from person to person. Consequently, standards and guidance that relate to environmental noise are typically presented in terms of criteria that would be expected to be considered acceptable by the majority of the population.

Operational Noise Predictions

11.5.20 Whilst there are several sound propagation models available, the ISO 9613 Part 2 [20] model has been used, this being identified as most appropriate for use in such rural sites [21]. The

specific interpretation of the ISO 9613 Part 2 propagation methodology recommended in the IOA GPG has been employed.

11.5.21 To carry out noise predictions it is assumed that:

- the turbines at the proposed wind farm are identical;
- the turbines radiate noise at the sound power levels specified in this report;
- the turbines are modelled as a point source at the hub-height of each; and,
- each residential property is assigned a reference height to simulate the presence of an observer.

11.5.22 The sound propagation model takes account of attenuation due to geometric spreading and atmospheric absorption corresponding to 10 ˚C and 70 % respectively, as provided within ISO 9613-1 [22]. Ground effects are also taken into account by the propagation model with a ground factor of 0.5 and a receiver height of 4 m used as recommended in the IOA GPG.

11.5.23 The barrier attenuations predicted by ISO 9613-2 have been shown to be significantly greater than those measured in practice under downwind conditions [23]. Therefore, barrier attenuation according to the ISO 9613-2 method has been discounted. In lieu of this, where there is no direct line of sight between the residential property in question and any part of the wind turbine, 2 dB attenuation has been assumed, as also recommended in the IOA GPG.

11.5.24 Verification studies have also shown that ISO 9613-2 tends to slightly underestimate noise levels at nearby dwellings in certain exceptional cases, notably in a valley type environment where the ground drops off between source and receiver [23]. In these instances, an addition of 3 dB has been applied to the resulting overall A weighted noise level as recommended by the IOA GPG. To generate the ground cross sections between each turbine and each dwelling necessary for reliable propagation modelling, ground contours at 5 m intervals for the area of interest have been generated from 50 m grid resolution digital terrain data.

11.5.25 Additionally, rather than making a conservative assumption that properties are always downwind of the wind farm, a more detailed assessment, which incorporates the effects of wind direction has been undertaken. This accounts for the fact that noise levels at a property will be less when the property is crosswind or upwind of the development. The directional attenuation factors applied, as shown in **Table 11.4**, are consistent with the recommendations of the IOA GPG, with reductions in noise of around 2 dB when a receiver is crosswind, and up to 10 dB when a receiver is upwind of a particular turbine. The IOA GPG also states that upwind reductions in noise level will only come into play gradually at distances of between 5 and 10 tip heights. As a result, these attenuation factors applied have been adjusted by the distance between the source and receiver accordingly.

Table 11.4 Directional Attenuation

Directionally Offset from Downwind (˚)	0	30	60	90	120	150	180	210	240	270	300	330
Directional Attenuation Factor, dB	0	0	0	-2.0	-6.7	-9.3	-10	-9.3	-6.7	-2.0	0	0

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

11.5.27 It has been shown by measurement-based verification studies [23] that the ISO 9613-2 model can provide a high degree of accuracy when calculating far field noise levels from elevated sources when the exceptional cases identified above are corrected for. Examples of conservative assumptions modelled which increase the likelihood of the calculated noise levels being an overestimate are that:

- although, in reality, the ground is predominantly porous (acoustically absorptive) it has been modelled as ‘mixed’, i.e. a combination of hard and porous,

corresponding to a ground absorption coefficient of 0.5 as recommended by the IOA GPG;

- receiver heights are modelled at 4 m above local ground level;
- trees and other non-terrain shielding effects have not been considered; and,
- an allowance for measurement uncertainty has been included in the sound power levels for the presented turbine.

11.5.28 The locations of the turbines which make up the proposed wind farm, and two potential neighbouring developments known as Trecelyn Wind Farm and Mynydd Llanhilleth Wind Farm are provided in **Table 11.5** and shown in **Figure 11.1: Mynydd Maen Noise Contour Plot**. The co-ordinates for the other cumulative sites are taken from information provided by the respective developers. The additional cumulative developments are currently at the scoping stage of planning and would not necessarily be required to be assessed here due to the various unknowns as to what the final designs will be for each. Nevertheless, an indicative cumulative operational assessment, using the original Trecelyn and Mynydd Llanhilleth layouts, has been undertaken to demonstrate that it is possible to operate all three of the sites considered herein whilst maintaining compliance with the overall requirements of ETSU-R-97. A series of indicative planning controls are suggested in the **Cumulative Effects** section which would help to ensure overall compliance with the requirements of ETSU-R-97 should all relevant developments be granted planning permission and become operational.

Table 11.5 Turbine Locations

Turbine ID	OSGB Co-Ordinates		Turbine ID	OSGB Co-Ordinates	
	X (m)	Y (m)		X (m)	Y (m)
MYNYDD MAEN			TRECELYN		
T1	325913	198742	C1	324042	198159
T2	326055	198482	C3	323229	196997
T3	325533	198792	C4	323120	196333
T4	325637	198388	C5	322863	195952
T5	325236	198351	MYNYDD LLANHILLETH		
T6	325063	198679	L1	324630	202630
T7	324847	198341	L2	323855	202860
T8	325883	198185	L3	323485	202270
T9	326383	197849	L4	323770	201740
T10	325567	197285	L5	324821	201806
T11	325733	197014	L6	324695	201115
T12	325720	196715	L7	324830	200715
T13	325779	196399	L8	323300	201000

11.5.29 The locations of the nearest residential properties to the turbines have been determined by inspection of relevant maps, address databases and via site visits. More residential properties may have been identified but have not been considered critical to this acoustic assessment and/or may be adequately represented by another residential property. The locations considered are listed in **Table 11.6** and are also shown in **Figure 11.1: Mynydd Maen Noise Contour Plot**.

Table 11.6 House Locations

House ID	House Name	OSGB Co-Ordinates	
		X (m)	Y (m)
H1	CRAIG LLYWARCH FARM	326210	194820
H2	LLANDERFEL FARM	326579	195374
H3	BROOK COTTAGE	326588	195429
H4	GARN WEN FARM	326734	196171
H5	ANNEX AT GARNWEN FARM	326727	196182
H6	GELLI-GRAVOG FARM	326837	196473
H7	BELLE VUE HOUSE	327336	196553
H8	CARAVAN TROED Y RHIW	326674	196560
H9	HIGH SPRING FARM	326661	196603

House ID	House Name	OSGB Co-Ordinates	
		X (m)	Y (m)
H10	TROED Y RHIW COTTAGE	326661	196603
H11	31 THE SQUARE	327144	196778
H12	2 MINESLOPE COTTAGE	327051	197041
H13	GLYN BRAN COTTAGE	327521	197242
H14	YEW TREE FARM	327593	197332
H15	LITTLE GREENMEADOW FARM	327513	197533
H16	WAIN HYWEL	327632	197700
H17	MOUNTAIN AIR	327721	197851
H18	WHITE HOUSE	327739	198286
H19	PEN Y CAEAU FARM	323260	198290
H20	TY-CARREG BARN	328158	198662
H21	TY CAREG BARN, CWRDY LANE	328158	198662
H22	PARISH COTTAGE	328043	198908
H23	CWMLICKEY BUNGALOW	327242	199064
H24	TY SHON SHENKIN	324071	199178
H25	BLAENDARE HOUSE	327114	199406
H26	SWALLOW BARN	324931	199624
H27	THE OLD SCHOOL HOUSE	324451	199628
H28	PWLL Y DOMEN COTTAGE	324974	199647
H29	MOUNTAINVIEW HOUSE	325371	199892
H30	WOODLAND FARM	325767	200086
H31	CRISPIN	326178	200117
H32	LEIGH BUNGALOW	326722	200296

11.5.30 The candidate turbine model for the proposed wind farm is the Vestas V117 4.2 MW turbine with a hub-height of 91.5 m and serrated trailing edge (STE) blade modifications. Furthermore, it is possible to operate this model of turbine in a variety of operational modes which may be implemented for numerous parameters not limited to wind speed, direction and time. Whilst the actual turbine to be procured and installed at the site is not yet finalised, this model is considered representative of a range of turbines, with similar dimensions and rated powers that could be installed. Acoustic emission data from the manufacturers' general specification for this machine is used in the analysis [24].

11.5.31 The assumed turbine model at the proposed Trecelyn Wind Farm site is also the Vestas V117 4.2 MW STE but with a hub height of 84 m. As such, the same acoustic emission data is used for the analysis but with a correction to account for the relative change in hub-height.

11.5.32 The candidate turbine model to be installed at the proposed Mynydd Llanhilleth Wind Farm development is the Vestas V150 4.2 MW STE with a hub-height of 105 m. Acoustic emission data from the manufacturer's general specification for this machine is used in the analysis [25].

11.5.33 The manufacturer for the turbines which could be potentially installed at each for the sites considered here has identified the sound power levels values as warranted. However, no independent test reports are currently available to indicate whether any margin for uncertainty has been incorporated into the levels. As a result, 2 dB has been added to the specified levels for all turbine models as a conservative measure and as recommended by the IOA GPG.

11.5.34 **Table 11.7** shows the overall sound power levels, including for a variety of operational modes which could be implemented at the proposed wind farm, over a range of standardised 10 m height wind speeds for the turbine models considered as part of the assessments (inc. cumulative) provided herein. **Table 11.8** shows the octave band noise levels corresponding to the maximum noise output for each respective turbine model, as also based on manufacturers specifications [26] [27], as provided separately, and including for the relevant uncertainty.

Table 11.7 Sound Power Levels, dB L_{WA}

Turbine	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
VESTAS V117 4.2 MW STE - 91.5 m HUB HEIGHT										
PO2	94.7	98.0	102.2	106.0	107.9	108.0	108.0	108.0	108.0	108.0
SO1	95.1	98.0	102.2	105.5	106.9	107.0	107.0	107.0	107.0	107.0
SO2	95.1	98.0	102.1	104.0	104.3	104.5	104.9	105.0	105.0	105.0
SO3	95.1	98.0	101.9	102.9	103.0	103.0	103.0	103.0	103.0	103.0
VESTAS V117 4.3 MW STE – 84 m HUB HEIGHT										
PO2	94.7	97.8	102.0	105.7	107.7	108.0	108.0	108.0	108.0	108.0
VESTAS V150 4.2 MW STE - 105 m HUB HEIGHT										
V150	94.3	97.8	102.6	106.0	106.9	106.9	106.9	106.9	106.9	106.9

Table 11.8 Octave Band Sound Power Levels, dB L_{WA}

Turbine	Overall, dB L_{WA}	Centre of Octave Band, Hz							
		63	125	250	500	1k	2k	4k	8k
VESTAS V117 4.3 MW STE - 91.5 m HUB HEIGHT									
PO2	108.0	88.4	95.5	100.2	102.5	102.4	99.8	94.9	87.5
VESTAS V117 4.3 MW STE – 84 m HUB HEIGHT									
PO2	108.0	88.4	95.5	100.2	102.5	102.4	99.8	94.9	87.5
VESTAS V150 4.2 MW STE - 105 m HUB HEIGHT									
Mode 0	106.9	88.3	95.6	100.2	101.9	100.9	97.0	90.5	80.9

11.5.35 The turbine models are assumed not to have any tonal noise output that would attract a penalty at neighbouring residences as per the requirements of ETSU-R-97. Nevertheless, a warranty or guarantee would be obtained from the manufacturer which limits the level of tonal noise associated with the operation of the individual turbines (or the site as a whole), should the site be granted planning consent and a finalised turbine model is procured. This would also help to provide appropriate recourse with the turbine manufacturer should tonal noise be present.

Construction Noise & Vibration

11.5.36 Construction noise is discussed with reference to Annex E of BS 5228-1:2009 which provides guidance on setting environmental noise targets. Several methods of assessing the significance of noise levels are presented in Annex E and the most applicable to the construction of the proposed wind farm is the ABC method.

11.5.37 The ABC method sets threshold noise levels for construction noise for specific periods based on the pre-existing ambient noise levels, subject to average lower Category A limiting values of 65, 55 and 45 dB L_{Aeq} for daytime (07:00 - 19:00 weekdays and Saturdays 07:00 – 13:00), evenings and weekends (19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays) and night-time (23:00 – 07:00) periods respectively, for instances where existing ambient noise levels are relatively low, which is the case here.

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

11.5.39 BS 6472-2:2008 details the maximum satisfactory magnitudes for vibration measured on a firm surface outside buildings with respect to human response. For up to three blast vibration events per day, the generally accepted maximum satisfactory magnitude at residential premises during daytime periods (08:00 – 18:00 Monday to Friday and 08:00 – 13:00 on Saturdays), is a peak particle velocity (ppv) of 6.0 to 10.0 mms^{-1}. In practice, the lower satisfactory magnitude should be used with the higher magnitude being justified on a case-by-case basis.

11.6 Baseline Conditions

Operational Noise

11.6.1 The proposed wind farm is located in a predominantly rural area approximately 2 km to the north-east of Cwmbran. The general noise character is typical of a rural environment with noise from farm machinery, livestock, birdsong, vehicle movements along local roads, distant traffic noise from more major through routes, watercourses, wind induced noise from trees and foliage and with the occasional aircraft passing overhead.

11.6.2 Background noise measurements were undertaken by RES at five locations neighbouring the proposed wind farm, in accordance with ETSU-R-97 and IOA GPG, and in consultation with the Environmental Health Officers representing Caerphilly County Borough Council and Torfaen County Borough Council. The survey locations are as detailed in **Table 11.9**.

Table 11.9 Background Noise Survey Locations

ID	House Name	Measurement Period		
		Start	End	Duration, days
H6	GELLI-GRAVOG FARM	17/10/2022	05/12/2022	50
H14	YEW TREE FARM	18/10/2022	05/12/2022	49
H19	PEN Y CAEAU FARM	17/10/2022	05/12/2022	50
H25	BLAENDARE HOUSE	17/10/2022	05/12/2022	50
H29	MOUNTAIN VIEW HOUSE	29/11/2022	15/02/2023	58

11.6.3 ETSU-R-97 made clear that background noise surveys are not required at all nearby properties, but only a sub-set thereof. In choosing survey locations the applicant has aimed to encompass properties where the greatest wind farm noise levels are predicted as well as locations geographically dispersed around the site to capture any variation in the background noise environment and represent the properties in the vicinity of the proposed wind farm. Where there are a group of properties in the vicinity of each other in a local area, a single representative survey location has been selected where the background noise levels are not expected to be consistently higher than the levels experienced at the other properties in the local area. The predicted wind rose, along with the impact of terrain sheltering and watercourses on the background noise levels, have also been taken into consideration when determining survey locations.

11.6.4 The background noise monitoring equipment was housed in weather-proof enclosures and powered by lead-acid batteries. The microphones were placed at a height of approximately 1.3 m above ground and equipped with all-weather wind shields which also provide water resistance and are designed to reduce the effects of wind-generated noise at the microphone. The sound level meters are certified by the manufacturer as meeting Type 1 / Class 1 precision standard in IEC 60651:1979 [28] and IEC 61672-1:2003 respectively [29].

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

11.6.6 The sound level meters were placed away from reflecting walls and vegetation. Photos of the equipment, in situ, are provided in **Technical Appendix 11.3**. The apparatus was calibrated before and after the survey period and the maximum drift detected was 0.2 dB, which is within the required range recommended in the IOA GPG. All instrumentation has been subject to laboratory calibration traceable to national standards within 24 months of deployment and field calibrators have been subject to laboratory calibration traceable to national standards within 12 months of deployment, as also recommended by the IOA GPG. Details are provided in **Technical Appendix 11.4**.

11.6.7 A remote sensing device employing LiDAR to measure wind conditions was located near to the centre of the proposed wind farm. Average wind speed and wind direction were measured for each 10-minute time period at a variety of heights above ground level, including directly at the hub height of the proposed turbines (91 m). The measurement data generated by the remote sensing device has been filtered to check its validity and to remove any anomalous

measurements. Prior to use in the data analysis, wind speed at the hub height has been converted to standardised 10 m height wind speed using the formula for roughness length shear profile as defined in Annex A of the IOA GPG. The wind direction used in the data analysis was also measured at the hub height.

11.6.8 **Figures 11.5.11 to 11.5.12** (see **Technical Appendix 11.5**) show the measured wind rose at the site over the background noise survey period at each survey position, as measured by the remote sensing device at hub height.

11.6.9 For illustrative purposes, **Figure 11.5.13** (see **Technical Appendix 11.5**) shows the measured wind rose over an extended 12-month period (13/04/2022 – 15/04/2023) as measured by the remote sensing device at hub height. As previously discussed, the noise prediction model employed is likely to overestimate the noise immission levels in instances where residential locations are not downwind of the turbines. **Figure 11.5.13** therefore may aid the reader as to the likelihood of over-estimation due to this factor.

11.6.10 The noise data has been cross-referenced with rainfall data measured at H6 (Gelli-Gravog Farm), using a tipping bucket rain gauge. Any noise data identified as having been affected by rainfall has been excluded from the data analysis as shown in **Figures 11.5.1 to 11.5.10** (see **Technical Appendix 11.5**).

11.6.11 Short-term periods of increased noise levels considered to be atypical have been removed from the dataset. The excluded data is shown **Figures 11.5.1 to 11.5.10** (see **Technical Appendix 11.5**).

11.6.12 Due to a malfunction with the power supply of the background noise monitoring equipment at survey location H29 (Mountain View House), the measurement period duration was reduced from 79 to 58 days of data measured.

11.6.13 All measurement data was measured according to Greenwich Mean Time (GMT). Wind speed, wind direction and acoustic measurements were made with the time marker giving the time value at the start of the 10-minute measurement interval. Rain measurements were made with the time marker giving the time value at the end of the 10-minute measurement interval. Data analysis was undertaken according to local time, with all data synchronised so that the time marker is the time value at the start of the 10-minute measurement interval.

11.6.14 **Figures 11.5.1 to 11.5.10** (see **Technical Appendix 11.5**) show the measured background noise levels correlated against wind speed for quiet daytime periods and night-time periods at each survey location in accordance with the IOA GPG recommendations. In each case, data points judged to be atypical or affected by rainfall have been excluded from the data analysis. A third-order polynomial 'best fit' line has been fitted to the resulting data where there are no fewer than 10 valid data points in any integer wind speed bin and the equation of the regression polynomial is provided. Where there are fewer than 10 valid data points within a given wind speed bin, the value of the 'best fit' line for preceding wind speed bin which contains no fewer than 10 valid data points has been adopted, where this occurs at relatively high wind speeds.

11.6.15 **Table 11.10** shows the levels corresponding to the best-fit lines fitted to the filtered background noise levels for quiet daytime and night-time periods respectively and at each of the measurement locations.

11.6.16 The corresponding daytime and night-time operational noise limits for the survey locations, for the same range of wind speeds, are provided in **Table 11.11**. In accordance with the definitions given in **Table 11.3**, operational noise limits are determined as L_B + 5 dB, with a lower fixed limit of 35 dB L_{A90} applied for quiet daytime and a lower fixed limit of 43 dB L_{A90} applied for night-time for all locations.

11.6.17 The baseline conditions would not be expected to change significantly under the "do nothing" scenario i.e. in the event that the Proposed Development is not granted planning permission and/or does not become operational.

Table 11.10 Derived Average (Best-Fit) Background Noise Levels, dB L_{A90}

ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
QUIET DAYTIME										
H6	31.0	31.5	32.2	33.0	33.8	34.7	35.7	36.6	37.5	38.3
H14	32.4	33.7	34.7	35.3	35.9	36.6	37.5	39.0	41.1	44.0
H19	28.9	30.5	32.3	34.3	36.3	38.2	39.8	40.9	41.5	41.5
H25	34.8	35.6	36.2	36.6	37.0	37.4	37.9	38.8	40.0	41.7
H29	32.8	33.5	34.1	34.8	35.6	36.6	37.8	39.3	41.1	43.3
NIGHT-TIME										
H6	31.3	31.9	32.3	32.6	33.0	33.4	34.0	34.8	35.9	35.9
H14	28.9	29.6	30.4	31.5	32.7	34.2	36.0	38.0	40.4	40.4
H19	24.7	26.0	27.7	29.7	32.0	34.4	36.9	39.4	41.8	44.0
H25	34.4	35.5	36.4	37.3	38.0	38.6	39.1	39.5	39.8	40.0
H29	26.2	26.2	26.7	27.8	29.4	31.3	33.6	36.1	38.8	41.6

Table 11.11 Operational Noise Limits, dB L_{A90}

ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
DAYTIME										
H6	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H14	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H19	35.0	35.5	37.3	39.3	41.3	43.2	44.8	45.9	46.5	46.5
H25	39.8	40.6	41.2	41.6	42.0	42.4	42.9	43.8	45.0	46.7
H29	37.8	38.5	39.1	39.8	40.6	41.6	42.8	44.3	46.1	48.3
NIGHT-TIME										
H6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H14	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H19	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.4	46.8	49.0
H25	43.0	43.0	43.0	43.0	43.0	43.6	44.1	44.5	44.8	45.0
H29	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	46.6

11.6.18 The derived noise limits are applied to each of the assessment locations identified in **Table 11.12** based on the relative proximity of the monitoring location to the assessment locations. Where there is ambiguity in this respect, the applied noise limits are applied on a basis that is considered conservative.

Table 11.12 Application of Noise Limits

ID	OSGB Co-Ordinates		Applied Noise Limit
	X (m)	Y (m)	
H1	326210	194820	H6 GELLI-GRAVOG FARM
H2	326579	195374	H6 GELLI-GRAVOG FARM
H3	326588	195429	H6 GELLI-GRAVOG FARM
H4	326734	196171	H6 GELLI-GRAVOG FARM
H5	326727	196182	H6 GELLI-GRAVOG FARM
H6	326837	196473	H6 GELLI-GRAVOG FARM
H7	327336	196553	H6 GELLI-GRAVOG FARM
H8	326674	196560	H6 GELLI-GRAVOG FARM
H9	326661	196603	H6 GELLI-GRAVOG FARM
H10	326661	196603	H6 GELLI-GRAVOG FARM
H11	327144	196778	H6 GELLI-GRAVOG FARM
H12	327051	197041	H6 GELLI-GRAVOG FARM
H13	327521	197242	H14 YEW TREE FARM
H14	327593	197332	H14 YEW TREE FARM
H15	327513	197533	H14 YEW TREE FARM
H16	327632	197700	H14 YEW TREE FARM
H17	327721	197851	H14 YEW TREE FARM

ID	OSGB Co-Ordinates		Applied Noise Limit
	X (m)	Y (m)	
H18	327739	198286	H14 YEW TREE FARM
H19	323260	198290	H19 PEN Y CAEAU FARM
H20	328158	198662	H14 YEW TREE FARM
H21	328158	198662	H14 YEW TREE FARM
H22	328043	198908	H14 YEW TREE FARM
H23	327242	199064	H25 BLAENDARE HOUSE
H24	324071	199178	H29 MOUNTAIN VIEW HOUSE
H25	327114	199406	H25 BLAENDARE HOUSE
H26	324931	199624	H29 MOUNTAIN VIEW HOUSE
H27	324451	199628	H29 MOUNTAIN VIEW HOUSE
H28	324974	199647	H29 MOUNTAIN VIEW HOUSE
H29	325371	199892	H29 MOUNTAIN VIEW HOUSE
H30	325767	200086	H29 MOUNTAIN VIEW HOUSE
H31	326178	200117	H29 MOUNTAIN VIEW HOUSE
H32	326722	200296	H29 MOUNTAIN VIEW HOUSE

11.6.19 **Table 11.13** shows the corresponding daytime and night-time noise limits at the residential assessment locations considered here. These limits are intended to apply to the combined impact of operational noise from the proposed wind farm with other existing, planned or permitted development near the site.

Table 11.13 Overall Noise Limits, dB L_{A90}

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
DAYTIME										
H1	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H2	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H3	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H4	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H5	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H6	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H7	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H8	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H9	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H10	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H11	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H12	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H13	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H14	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H15	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H16	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H17	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H18	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H19	35.0	35.5	37.3	39.3	41.3	43.2	44.8	45.9	46.5	46.5
H20	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H21	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H22	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H23	39.8	40.6	41.2	41.6	42.0	42.4	42.9	43.8	45.0	46.7
H24	37.8	38.5	39.1	39.8	40.6	41.6	42.8	44.3	46.1	48.3
H25	39.8	40.6	41.2	41.6	42.0	42.4	42.9	43.8	45.0	46.7
H26	37.8	38.5	39.1	39.8	40.6	41.6	42.8	44.3	46.1	48.3
H27	37.8	38.5	39.1	39.8	40.6	41.6	42.8	44.3	46.1	48.3
H28	37.8	38.5	39.1	39.8	40.6	41.6	42.8	44.3	46.1	48.3
H29	37.8	38.5	39.1	39.8	40.6	41.6	42.8	44.3	46.1	48.3
H30	37.8	38.5	39.1	39.8	40.6	41.6	42.8	44.3	46.1	48.3
H31	37.8	38.5	39.1	39.8	40.6	41.6	42.8	44.3	46.1	48.3

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
H32	37.8	38.5	39.1	39.8	40.6	41.6	42.8	44.3	46.1	48.3
NIGHT-TIME										
H1	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H2	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H3	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H5	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H7	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H8	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H9	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H10	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H11	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H12	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H13	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H14	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H15	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H16	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H17	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H18	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H19	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.4	46.8	49.0
H20	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H21	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H22	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H23	43.0	43.0	43.0	43.0	43.0	43.6	44.1	44.5	44.8	45.0
H24	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	46.6
H25	43.0	43.0	43.0	43.0	43.0	43.6	44.1	44.5	44.8	45.0
H26	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	46.6
H27	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	46.6
H28	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	46.6
H29	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	46.6
H30	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	46.6
H31	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	46.6
H32	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.8	46.6

Construction Noise

11.6.20 The background/baseline noise levels detailed above are relatively low, as would be expected for a rural area such as that considered here, and existing ambient noise levels are also considered low. As a result, lower limiting values, as discussed previously with reference to the 'ABC method' provided within BS 5228-1, are used to inform discussion as to the potential impacts during construction.

11.6.21 Existing sources of vibration in the area are expected to be related to HGV movements along local roads, localised construction/maintenance activities and the occasional earthquake and/or tremor, which may well be perceptible to people in the locale but with a certain level of habituation for some residents depending on the source. In general, existing sources of vibration are expected to be intermittent and would not be expected to be significant in terms of normal guidance in this respect.

11.7 Potential Impacts

Operational Noise

11.7.1 **Table 11.14** shows the maximum predicted operational noise levels for any given wind direction (i.e. downwind in this instance) resulting from the introduction of the proposed wind farm operating in isolation at the nearest residential properties using the methodology detailed above and over a range of wind speeds.

Table 11.14 Mynydd Maen Wind Farm Predicted Operational Noise Levels, dB L_{A90}

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
H1	18.4	21.7	25.9	29.7	31.6	31.7	31.7	31.7	31.7	31.7
H2	19.5	22.8	27.0	30.8	32.7	32.8	32.8	32.8	32.8	32.8
H3	19.8	23.1	27.3	31.1	33.0	33.1	33.1	33.1	33.1	33.1
H4	23.8	27.1	31.3	35.1	37.0	37.1	37.1	37.1	37.1	37.1
H5	23.9	27.2	31.4	35.2	37.1	37.2	37.2	37.2	37.2	37.2
H6	24.4	27.7	31.9	35.7	37.6	37.7	37.7	37.7	37.7	37.7
H7	22.9	26.2	30.4	34.2	36.1	36.2	36.2	36.2	36.2	36.2
H8	25.2	28.5	32.7	36.5	38.4	38.5	38.5	38.5	38.5	38.5
H9	25.5	28.8	33.0	36.8	38.7	38.8	38.8	38.8	38.8	38.8
H10	25.5	28.8	33.0	36.8	38.7	38.8	38.8	38.8	38.8	38.8
H11	23.5	26.8	31.0	34.8	36.7	36.8	36.8	36.8	36.8	36.8
H12	24.6	27.9	32.1	35.9	37.8	37.9	37.9	37.9	37.9	37.9
H13	22.3	25.6	29.8	33.6	35.5	35.6	35.6	35.6	35.6	35.6
H14	22.8	26.1	30.3	34.1	36.0	36.1	36.1	36.1	36.1	36.1
H15	23.7	27.0	31.2	35.0	36.9	37.0	37.0	37.0	37.0	37.0
H16	23.2	26.5	30.7	34.5	36.4	36.5	36.5	36.5	36.5	36.5
H17	22.8	26.1	30.3	34.1	36.0	36.1	36.1	36.1	36.1	36.1
H18	21.2	24.5	28.7	32.5	34.4	34.5	34.5	34.5	34.5	34.5
H19	22.1	25.4	29.6	33.4	35.3	35.4	35.4	35.4	35.4	35.4
H20	20.5	23.8	28.0	31.8	33.7	33.8	33.8	33.8	33.8	33.8
H21	20.5	23.8	28.0	31.8	33.7	33.8	33.8	33.8	33.8	33.8
H22	21.2	24.5	28.7	32.5	34.4	34.5	34.5	34.5	34.5	34.5
H23	23.0	26.2	30.4	34.2	36.1	36.3	36.3	36.3	36.3	36.3
H24	27.4	30.7	34.9	38.7	40.6	40.7	40.7	40.7	40.7	40.7
H25	22.1	25.4	29.6	33.4	35.3	35.4	35.4	35.4	35.4	35.4
H26	29.1	32.4	36.6	40.4	42.3	42.4	42.4	42.4	42.4	42.4
H27	27.4	30.7	34.9	38.7	40.6	40.7	40.7	40.7	40.7	40.7
H28	29.2	32.5	36.7	40.5	42.4	42.5	42.5	42.5	42.5	42.5
H29	28.2	31.5	35.7	39.5	41.4	41.5	41.5	41.5	41.5	41.5
H30	26.7	30.0	34.2	38.0	39.9	40.0	40.0	40.0	40.0	40.0
H31	23.8	27.1	31.3	35.1	37.0	37.1	37.1	37.1	37.1	37.1
H32	20.1	23.4	27.6	31.4	33.3	33.4	33.4	33.4	33.4	33.4

11.7.2 **Table 11.15** shows the margin by which the predicted operational noise levels resulting from the introduction of the proposed wind farm meets the noise limits set out in **Table 11.13**. A positive number indicates that predicted **levels** are above the noise limits. This assessment essentially assumes that only the proposed wind farm would be granted planning consent and that the full extent of the derived ETSU-R-97 noise limits would apply as a result.

Table 11.15 Mynydd Maen Wind Farm Predicted Margin of Compliance, dB

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
DAYTIME										
H1	-17.6	-14.8	-11.3	-8.3	-7.2	-8.0	-9.0	-9.9	-10.8	-11.6
H2	-16.5	-13.7	-10.2	-7.2	-6.1	-6.9	-7.9	-8.8	-9.7	-10.5
H3	-16.2	-13.4	-9.9	-6.9	-5.8	-6.6	-7.6	-8.5	-9.4	-10.2

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
H4	-12.2	-9.4	-5.9	-2.9	-1.8	-2.6	-3.6	-4.5	-5.4	-6.2
H5	-12.1	-9.3	-5.8	-2.8	-1.7	-2.5	-3.5	-4.4	-5.3	-6.1
H6	-11.6	-8.8	-5.3	-2.3	-1.2	-2.0	-3.0	-3.9	-4.8	-5.6
H7	-13.1	-10.3	-6.8	-3.8	-2.7	-3.5	-4.5	-5.4	-6.3	-7.1
H8	-10.8	-8.0	-4.5	-1.5	-0.4	-1.2	-2.2	-3.1	-4.0	-4.8
H9	-10.5	-7.7	-4.2	-1.2	-0.1	-0.9	-1.9	-2.8	-3.7	-4.5
H10	-10.5	-7.7	-4.2	-1.2	-0.1	-0.9	-1.9	-2.8	-3.7	-4.5
H11	-12.5	-9.7	-6.2	-3.2	-2.1	-2.9	-3.9	-4.8	-5.7	-6.5
H12	-11.4	-8.6	-5.1	-2.1	-1.0	-1.8	-2.8	-3.7	-4.6	-5.4
H13	-15.1	-13.1	-9.9	-6.7	-5.4	-6.0	-6.9	-8.4	-10.5	-13.4
H14	-14.6	-12.6	-9.4	-6.2	-4.9	-5.5	-6.4	-7.9	-10.0	-12.9
H15	-13.7	-11.7	-8.5	-5.3	-4.0	-4.6	-5.5	-7.0	-9.1	-12.0
H16	-14.2	-12.2	-9.0	-5.8	-4.5	-5.1	-6.0	-7.5	-9.6	-12.5
H17	-14.6	-12.6	-9.4	-6.2	-4.9	-5.5	-6.4	-7.9	-10.0	-12.9
H18	-16.2	-14.2	-11.0	-7.8	-6.5	-7.1	-8.0	-9.5	-11.6	-14.5
H19	-12.9	-10.1	-7.7	-5.9	-6.0	-7.8	-9.4	-10.5	-11.1	-11.1
H20	-16.9	-14.9	-11.7	-8.5	-7.2	-7.8	-8.7	-10.2	-12.3	-15.2
H21	-16.9	-14.9	-11.7	-8.5	-7.2	-7.8	-8.7	-10.2	-12.3	-15.2
H22	-16.2	-14.2	-11.0	-7.8	-6.5	-7.1	-8.0	-9.5	-11.6	-14.5
H23	-16.8	-14.4	-10.8	-7.4	-5.9	-6.1	-6.6	-7.5	-8.7	-10.4
H24	-10.4	-7.8	-4.2	-1.1	0.0	-0.9	-2.1	-3.6	-5.4	-7.6
H25	-17.7	-15.2	-11.6	-8.2	-6.7	-7.0	-7.5	-8.4	-9.6	-11.3
H26	-8.7	-6.1	-2.5	0.6	1.7	0.8	-0.4	-1.9	-3.7	-5.9
H27	-10.4	-7.8	-4.2	-1.1	0.0	-0.9	-2.1	-3.6	-5.4	-7.6
H28	-8.6	-6.0	-2.4	0.7	1.8	0.9	-0.3	-1.8	-3.6	-5.8
H29	-9.6	-7.0	-3.4	-0.3	0.8	-0.1	-1.3	-2.8	-4.6	-6.8
H30	-11.1	-8.5	-4.9	-1.8	-0.7	-1.6	-2.8	-4.3	-6.1	-8.3
H31	-14.0	-11.4	-7.8	-4.7	-3.6	-4.5	-5.7	-7.2	-9.0	-11.2
H32	-17.7	-15.1	-11.5	-8.4	-7.3	-8.2	-9.4	-10.9	-12.7	-14.9
NIGHT-TIME										
H1	-24.6	-21.3	-17.1	-13.3	-11.4	-11.3	-11.3	-11.3	-11.3	-11.3
H2	-23.5	-20.2	-16.0	-12.2	-10.3	-10.2	-10.2	-10.2	-10.2	-10.2
H3	-23.2	-19.9	-15.7	-11.9	-10.0	-9.9	-9.9	-9.9	-9.9	-9.9
H4	-19.2	-15.9	-11.7	-7.9	-6.0	-5.9	-5.9	-5.9	-5.9	-5.9
H5	-19.1	-15.8	-11.6	-7.8	-5.9	-5.8	-5.8	-5.8	-5.8	-5.8
H6	-18.6	-15.3	-11.1	-7.3	-5.4	-5.3	-5.3	-5.3	-5.3	-5.3
H7	-20.1	-16.8	-12.6	-8.8	-6.9	-6.8	-6.8	-6.8	-6.8	-6.8
H8	-17.8	-14.5	-10.3	-6.5	-4.6	-4.5	-4.5	-4.5	-4.5	-4.5
H9	-17.5	-14.2	-10.0	-6.2	-4.3	-4.2	-4.2	-4.2	-4.2	-4.2
H10	-17.5	-14.2	-10.0	-6.2	-4.3	-4.2	-4.2	-4.2	-4.2	-4.2
H11	-19.5	-16.2	-12.0	-8.2	-6.3	-6.2	-6.2	-6.2	-6.2	-6.2
H12	-18.4	-15.1	-10.9	-7.1	-5.2	-5.1	-5.1	-5.1	-5.1	-5.1
H13	-20.7	-17.4	-13.2	-9.4	-7.5	-7.4	-7.4	-7.4	-9.8	-9.8
H14	-20.2	-16.9	-12.7	-8.9	-7.0	-6.9	-6.9	-6.9	-9.3	-9.3
H15	-19.3	-16.0	-11.8	-8.0	-6.1	-6.0	-6.0	-6.0	-8.4	-8.4
H16	-19.8	-16.5	-12.3	-8.5	-6.6	-6.5	-6.5	-6.5	-8.9	-8.9
H17	-20.2	-16.9	-12.7	-8.9	-7.0	-6.9	-6.9	-6.9	-9.3	-9.3
H18	-21.8	-18.5	-14.3	-10.5	-8.6	-8.5	-8.5	-8.5	-10.9	-10.9
H19	-20.9	-17.6	-13.4	-9.6	-7.7	-7.6	-7.6	-9.0	-11.4	-13.6
H20	-22.5	-19.2	-15.0	-11.2	-9.3	-9.2	-9.2	-9.2	-11.6	-11.6
H21	-22.5	-19.2	-15.0	-11.2	-9.3	-9.2	-9.2	-9.2	-11.6	-11.6
H22	-21.8	-18.5	-14.3	-10.5	-8.6	-8.5	-8.5	-8.5	-10.9	-10.9
H23	-20.0	-16.8	-12.6	-8.8	-6.9	-7.3	-7.8	-8.2	-8.5	-8.7
H24	-15.6	-12.3	-8.1	-4.3	-2.4	-2.3	-2.3	-2.3	-3.1	-5.9
H25	-20.9	-17.6	-13.4	-9.6	-7.7	-8.2	-8.7	-9.1	-9.4	-9.6

House ID	Standardised 10 m Height Wind Speed, m.s^{-1}									
	3	4	5	6	7	8	9	10	11	12
H26	-13.9	-10.6	-6.4	-2.6	-0.7	-0.6	-0.6	-0.6	-1.4	-4.2
H27	-15.6	-12.3	-8.1	-4.3	-2.4	-2.3	-2.3	-2.3	-3.1	-5.9
H28	-13.8	-10.5	-6.3	-2.5	-0.6	-0.5	-0.5	-0.5	-1.3	-4.1
H29	-14.8	-11.5	-7.3	-3.5	-1.6	-1.5	-1.5	-1.5	-2.3	-5.1
H30	-16.3	-13.0	-8.8	-5.0	-3.1	-3.0	-3.0	-3.0	-3.8	-6.6
H31	-19.2	-15.9	-11.7	-7.9	-6.0	-5.9	-5.9	-5.9	-6.7	-9.5
H32	-22.9	-19.6	-15.4	-11.6	-9.7	-9.6	-9.6	-9.6	-10.4	-13.2

11.7.3 The results indicate that the predicted noise levels would be up to 1.8 dB above the applied daytime noise limits for standardised 10 m height wind speeds of around 6 to 8 m.s^{-1} at H26, H28 and H29. Although, this would only occur for certain wind directions. The night-time noise limits are predicted to be met in all instances.

11.7.4 As a result, mitigation measures, in the form of curtailment of the turbines to be installed at the site have been prescribed such that the derived daytime noise limits can be met, as detailed in **Section 11.8**.

Construction Noise & Vibration

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

11.7.6 The exact methodology and timing of construction activities have not yet been defined and a reliable assessment of expected construction noise levels is not possible as a result. However, as discussed in **Section 11.2**, works expected to be undertaken at or around the proposed turbine locations would occur at distances that are unlikely result in noise levels that would breach typical criteria at neighbouring residences in this regard.

11.7.7 The access route for the proposed wind farm is expected to pass reasonably close to some dwellings to the north and west of the site and with some upgrade works to existing access tracks and local roads **also** expected to occur in close proximity to some dwellings. In these instances, the level of noise generated by construction works could be close to the limits defined as part of the 'ABC method' discussed earlier. As a result, typical construction noise mitigation measures are provided in **Section 11.8** which aim to minimise noise as far as reasonably practicable and/or reasonable.

11.7.8 The movement of additional vehicles, including heavy goods vehicles (HGVs), along local roads and access routes may well be noticeable to residents adjacent to these in terms of the noise and vibration generated by them. The resultant impacts on local roads, that are already well used by local traffic and existing HGV movements, would be relatively minor in terms of the increase in average noise levels resulting from the additional vehicles on the roads. However, the individual events may well be noticeable to residents, with resulting levels for individual events being similar to that created by existing HGV movements. The resultant noise levels on parts of the route that are less well used by existing traffic would be noticeable to residents located along the route. However, the resultant noise and vibration levels from vehicles passing the dwellings would be unlikely to breach the adopted construction noise limits and accepted vibration thresholds.

11.7.9 There are no specific noise limits for blasting activities and no means of predicting the potential level of sound from a particular blast, regardless of the charge size, is provided within BS 5228-1. However, the intermittent noise generated may well be audible and alarming/starling to residents, pets and local wildlife. As a result, whilst noise from blasting is not considered to be injurious to humans at typical setback distances, as is the case here, the adoption of good practice to minimise the inherent impulsive noise from each blast and to inform residents as to when these activities will occur is vital. Whilst the sound may be audible, the level of noise, overpressure and vibration generated by each blast will be well below levels that would be expected to cause damage to the nearest housing and/or

structures. **Section 11.8** provides details as to standard mitigation measures to be incorporated into the blasting processes and may also be included within the CEMP.

11.8 Mitigation

Operational Noise

11.8.1 The initial assessment presented within **Section 11.7** identifies that predicted operational noise levels may be above the daytime noise limits at some locations neighbouring the proposed wind farm.

11.8.2 As a result of the above, a mitigation/curtailment strategy has been determined, which accounts for the wind regime at the site, the noise limits, the various power curves and overall noise levels associated with the operational modes detailed in **Table 11.7**, with a view to minimising the potential losses in generating capacity resulting from the potential implementation of the strategy. The proprietary in-house RES methodology for determining the curtailment scenario incorporates optimisation techniques to provide an expected best outcome in terms of potential overall generating capacity whilst maintaining compliance with the limiting requirements in terms of operational noise.

11.8.3 The curtailment strategy, as presented in **Technical Appendix 11.6**, results in predicted noise levels that would meet the requirements of ETSU-R-97 for daytime periods. The predicted noise levels and corresponding margins of compliance for daytime periods are shown in **Table 11.16** and **Table 11.17** respectively.

11.8.4 This demonstrates that the requirements of ETSU-R-97 can be met provided that an appropriate operational noise curtailment strategy is applied at the proposed wind farm.

Table 11.16 Curtailed Mynydd Maen Wind Farm Daytime Noise Levels, dB L_{A90}

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
H1	18.4	21.7	25.9	29.7	31.6	31.7	31.7	31.7	31.7	31.7
H2	19.5	22.8	27.0	30.8	32.7	32.8	32.8	32.8	32.8	32.8
H3	19.8	23.1	27.3	31.1	33.0	33.1	33.1	33.1	33.1	33.1
H4	23.8	27.1	31.3	35.1	37.0	37.1	37.1	37.1	37.1	37.1
H5	23.9	27.2	31.4	35.2	37.1	37.2	37.2	37.2	37.2	37.2
H6	24.4	27.7	31.9	35.7	37.6	37.7	37.7	37.7	37.7	37.7
H7	22.9	26.2	30.4	34.2	36.1	36.2	36.2	36.2	36.2	36.2
H8	25.2	28.5	32.7	36.5	38.4	38.5	38.5	38.5	38.5	38.5
H9	25.5	28.8	33.0	36.8	38.7	38.8	38.8	38.8	38.8	38.8
H10	25.5	28.8	33.0	36.8	38.7	38.8	38.8	38.8	38.8	38.8
H11	23.5	26.8	31.0	34.8	36.7	36.8	36.8	36.8	36.8	36.8
H12	24.6	27.9	32.1	35.9	37.8	37.9	37.9	37.9	37.9	37.9
H13	22.3	25.6	29.8	33.6	35.5	35.6	35.6	35.6	35.6	35.6
H14	22.8	26.1	30.3	34.1	36.0	36.1	36.1	36.1	36.1	36.1
H15	23.7	27.0	31.2	35.0	36.9	37.0	37.0	37.0	37.0	37.0
H16	23.2	26.5	30.7	34.5	36.4	36.5	36.5	36.5	36.5	36.5
H17	22.8	26.1	30.3	34.1	36.0	36.1	36.1	36.1	36.1	36.1
H18	21.2	24.5	28.7	32.5	34.4	34.5	34.5	34.5	34.5	34.5
H19	22.1	25.4	29.6	33.4	35.3	35.4	35.4	35.4	35.4	35.4
H20	20.5	23.8	28.0	31.8	33.7	33.8	33.8	33.8	33.8	33.8
H21	20.5	23.8	28.0	31.8	33.7	33.8	33.8	33.8	33.8	33.8
H22	21.2	24.5	28.7	32.5	34.4	34.5	34.5	34.5	34.5	34.5
H23	23.0	26.2	30.4	34.2	36.1	36.3	36.3	36.3	36.3	36.3
H24	27.4	30.7	34.9	38.7	40.5	40.7	40.7	40.7	40.7	40.7
H25	22.1	25.4	29.6	33.4	35.3	35.4	35.4	35.4	35.4	35.4
H26	29.1	32.4	36.6	39.8	40.6	41.6	42.4	42.4	42.4	42.4
H27	27.4	30.7	34.9	38.4	39.6	40.2	40.7	40.7	40.7	40.7
H28	29.2	32.5	36.7	39.8	40.6	41.6	42.5	42.5	42.5	42.5
H29	28.2	31.5	35.7	39.1	40.2	41.1	41.5	41.5	41.5	41.5

House ID	Standardised 10 m Height Wind Speed, m.s^{-1}									
	3	4	5	6	7	8	9	10	11	12
H30	26.7	30.0	34.2	38.0	39.3	40.0	40.0	40.0	40.0	40.0
H31	23.8	27.1	31.3	35.1	36.7	37.1	37.1	37.1	37.1	37.1
H32	20.1	23.4	27.6	31.4	33.3	33.4	33.4	33.4	33.4	33.4

Table 11.17 Curtailed Daytime Mynydd Maen Wind Farm Margin of Compliance, dB

House ID	Standardised 10 m Height Wind Speed, m.s^{-1}									
	3	4	5	6	7	8	9	10	11	12
H1	-17.6	-14.8	-11.3	-8.3	-7.2	-8.0	-9.0	-9.9	-10.8	-11.6
H2	-16.5	-13.7	-10.2	-7.2	-6.1	-6.9	-7.9	-8.8	-9.7	-10.5
H3	-16.2	-13.4	-9.9	-6.9	-5.8	-6.6	-7.6	-8.5	-9.4	-10.2
H4	-12.2	-9.4	-5.9	-2.9	-1.8	-2.6	-3.6	-4.5	-5.4	-6.2
H5	-12.1	-9.3	-5.8	-2.8	-1.7	-2.5	-3.5	-4.4	-5.3	-6.1
H6	-11.6	-8.8	-5.3	-2.3	-1.2	-2.0	-3.0	-3.9	-4.8	-5.6
H7	-13.1	-10.3	-6.8	-3.8	-2.7	-3.5	-4.5	-5.4	-6.3	-7.1
H8	-10.8	-8.0	-4.5	-1.5	-0.4	-1.2	-2.2	-3.1	-4.0	-4.8
H9	-10.5	-7.7	-4.2	-1.2	-0.1	-0.9	-1.9	-2.8	-3.7	-4.5
H10	-10.5	-7.7	-4.2	-1.2	-0.1	-0.9	-1.9	-2.8	-3.7	-4.5
H11	-12.5	-9.7	-6.2	-3.2	-2.1	-2.9	-3.9	-4.8	-5.7	-6.5
H12	-11.4	-8.6	-5.1	-2.1	-1.0	-1.8	-2.8	-3.7	-4.6	-5.4
H13	-15.1	-13.1	-9.9	-6.7	-5.4	-6.0	-6.9	-8.4	-10.5	-13.4
H14	-14.6	-12.6	-9.4	-6.2	-4.9	-5.5	-6.4	-7.9	-10.0	-12.9
H15	-13.7	-11.7	-8.5	-5.3	-4.0	-4.6	-5.5	-7.0	-9.1	-12.0
H16	-14.2	-12.2	-9.0	-5.8	-4.5	-5.1	-6.0	-7.5	-9.6	-12.5
H17	-14.6	-12.6	-9.4	-6.2	-4.9	-5.5	-6.4	-7.9	-10.0	-12.9
H18	-16.2	-14.2	-11.0	-7.8	-6.5	-7.1	-8.0	-9.5	-11.6	-14.5
H19	-12.9	-10.1	-7.7	-5.9	-6.0	-7.8	-9.4	-10.5	-11.1	-11.1
H20	-16.9	-14.9	-11.7	-8.5	-7.2	-7.8	-8.7	-10.2	-12.3	-15.2
H21	-16.9	-14.9	-11.7	-8.5	-7.2	-7.8	-8.7	-10.2	-12.3	-15.2
H22	-16.2	-14.2	-11.0	-7.8	-6.5	-7.1	-8.0	-9.5	-11.6	-14.5
H23	-16.8	-14.4	-10.8	-7.4	-5.9	-6.1	-6.6	-7.5	-8.7	-10.4
H24	-10.4	-7.8	-4.2	-1.1	-0.1	-0.9	-2.1	-3.6	-5.4	-7.6
H25	-17.7	-15.2	-11.6	-8.2	-6.7	-7.0	-7.5	-8.4	-9.6	-11.3
H26	-8.7	-6.1	-2.5	0.0	0.0	0.0	-0.4	-1.9	-3.7	-5.9
H27	-10.4	-7.8	-4.2	-1.4	-1.0	-1.4	-2.1	-3.6	-5.4	-7.6
H28	-8.6	-6.0	-2.4	0.0	0.0	0.0	-0.3	-1.8	-3.6	-5.8
H29	-9.6	-7.0	-3.4	-0.7	-0.4	-0.5	-1.3	-2.8	-4.6	-6.8
H30	-11.1	-8.5	-4.9	-1.8	-1.3	-1.6	-2.8	-4.3	-6.1	-8.3
H31	-14.0	-11.4	-7.8	-4.7	-3.9	-4.5	-5.7	-7.2	-9.0	-11.2
H32	-17.7	-15.1	-11.5	-8.4	-7.3	-8.2	-9.4	-10.9	-12.7	-14.9

Construction Noise & Vibration

11.8.5 For all activities, measures would be taken to reduce noise levels with due regard to practicality and cost as per the concept of 'best practicable means' as defined in Section 72 of the Control of Pollution Act 1974 [17].

11.8.6 BS 5228-1 states that the 'attitude of the contractor' is important in minimising the likelihood of complaints and therefore consultation with the local authority along with letter drops are advised to inform residents of intended activity. Non-acoustic factors, which influence the overall level of complaints such as mud on roads and dust generation, would also be controlled through construction practices adopted on the site and managed via a Construction and Environmental Management Plan (CEMP). Furthermore, the following noise mitigation options will be implemented where appropriate:

- Consideration would be given to noise emissions when selecting plant and equipment to be used at the site;

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

11.8.7 Site construction operations would be limited to 07:00 – 19:00 Monday to Friday, and 07:00 – 13:00 on Saturdays except during turbine erection and commissioning or during periods of emergency work.

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

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

- Good practice on blasting shall be followed;
- The vibration and air overpressure reduction methods outlined in Section 8.6.9.2 of BS 5228-2:2009 shall be adhered to where appropriate and/or necessary;
- Advance warning shall be given to nearby residents;
- Blasting should only occur between the hours of 08:00 - 18:00 on Mondays-Fridays or between the hours of 08:00 - 13:00 on Saturdays; and
- No more than three blasts per day should occur.

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

11.8.11 As with operational noise, if planning permission is granted for the proposed wind farm, planning conditions can be proposed so that appropriate noise mitigation measures and construction practices are included within a CEMP.

11.9 Residual Effects

Operational Noise

11.9.1 The acoustic assessment demonstrates that predicted noise levels from the proposed wind farm at residential properties do not exceed the derived noise limits across all wind speeds provided that an operational noise mitigation/curtailment strategy is adopted. Therefore, no significant impacts in terms of operational noise are expected. This should not be interpreted to mean that operational noise would be inaudible (or masked by background noise) under all conditions, but that the levels of noise are acceptable under ETSU-R-97 and associated guidance.

11.9.2 The actual curtailment strategy would depend on the actual turbine to be procured and installed at the site should planning consent be granted.

Construction Noise & Vibration

11.9.3 Noise and vibration during the construction of the proposed wind farm, may well be audible and/or perceptible to people residing in the area, but the levels would be below established noise limits and planning requirements in this respect due to the large distances between the site and the surrounding dwellings. Where construction noise relating to the provision of access to the site, including the upgrade of local roads and their use thereof, is expected to occur in close proximity to residences, enhanced mitigation measures would be adopted to reduce noise and vibration where necessary. The impacts resulting from blasting at 'borrow

pits' are only considered in terms of the steps to limit any resulting impact through appropriate blast design and best practice, which also involves keeping residents informed as to planned blasting activities, with no significant impacts being expected.

11.10 Cumulative Effects

Operational Noise

11.10.1 An additional assessment has been undertaken which incorporates the predicted operational noise levels from the proposed wind farm operating at the same time (i.e. cumulatively) with the planned developments known as Trecelyn Wind Farm and Mynydd Llanhilleth Wind Farm. An indicative assessment has been undertaken to demonstrate that it is possible to operate all three of the sites considered herein whilst maintaining compliance with the overall requirements of ETSU-R-97.

11.10.2 These additional wind farms are within 5 km of the Proposed Development and have common neighbouring residences which could have increased operational noise as a result of their operation. Other wind farms located outside this radius would not have a significant impact on the residences considered within this Chapter and have not been considered further as a result.

11.10.3 The ETSU-R-97 assessment methodology only accounts for noise generated by the operation of wind farms. Other existing or proposed noise generating facilities would either be considered as part of the existing baseline/background noise environment, would contribute to the 'future baseline' or would be subject to their own assessment criteria, such as that specified within BS 4142. Other existing or potential noise generating facilities have not been considered further here as a result.

11.10.4 This section also provides a list of suggested planning condition limits which may be applied to each wind farm site respectively to ensure the overall requirements of ETSU-R-97 would be met. However, the specific means of potential curtailment of certain turbines would be the responsibility of the eventual site operators and will depend on the specific turbine models to be installed at each of the potential developments.

11.10.5 The preliminary layouts and assumptions used for the cumulative assessment are shown in **Section 11.5**.

11.10.6 **Table 11.18** shows the maximum predicted operational noise levels for any given wind direction resulting from the combined unrestricted operation of the developments at the nearest residential properties using the methodology detailed above and over a range of wind speeds. **Figure 11.2** shows the maximum cumulative noise levels resulting from the introduction of all three developments assuming that all properties would be downwind of the sites simultaneously, which clearly cannot occur in practice.

Table 11.18 Overall Predicted Cumulative Operational Noise Levels, dB L_{A90}

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
H1	19.3	22.6	26.8	30.6	32.5	32.6	32.6	32.6	32.6	32.6
H2	20.2	23.5	27.7	31.5	33.3	33.4	33.4	33.4	33.4	33.4
H3	20.5	23.8	28.0	31.8	33.6	33.8	33.8	33.8	33.8	33.8
H4	24.1	27.4	31.6	35.4	37.3	37.4	37.4	37.4	37.4	37.4
H5	24.2	27.5	31.7	35.5	37.4	37.5	37.5	37.5	37.5	37.5
H6	24.7	28.0	32.2	36.0	37.9	38.0	38.0	38.0	38.0	38.0
H7	23.2	26.5	30.7	34.5	36.4	36.5	36.5	36.5	36.5	36.5
H8	25.5	28.8	33.0	36.8	38.6	38.7	38.7	38.7	38.7	38.7
H9	25.7	29.0	33.2	37.0	38.9	39.0	39.0	39.0	39.0	39.0
H10	25.7	29.0	33.2	37.0	38.9	39.0	39.0	39.0	39.0	39.0
H11	23.8	27.1	31.3	35.1	37.0	37.1	37.1	37.1	37.1	37.1
H12	24.9	28.2	32.4	36.2	38.1	38.2	38.2	38.2	38.2	38.2
H13	22.7	26.0	30.2	34.0	35.8	35.9	35.9	35.9	35.9	35.9
H14	23.2	26.5	30.7	34.5	36.3	36.4	36.4	36.4	36.4	36.4
H15	24.0	27.4	31.6	35.4	37.2	37.3	37.3	37.3	37.3	37.3

House ID	Standardised 10 m Height Wind Speed, m.s^{-1}									
	3	4	5	6	7	8	9	10	11	12
H16	23.6	26.9	31.1	34.9	36.7	36.8	36.8	36.8	36.8	36.8
H17	23.1	26.4	30.7	34.5	36.3	36.4	36.4	36.4	36.4	36.4
H18	21.8	25.1	29.4	33.2	35.0	35.1	35.1	35.1	35.1	35.1
H19	26.3	29.5	33.8	37.5	39.4	39.6	39.6	39.6	39.6	39.6
H20	21.3	24.6	28.9	32.7	34.4	34.5	34.5	34.5	34.5	34.5
H21	21.3	24.6	28.9	32.7	34.4	34.5	34.5	34.5	34.5	34.5
H22	22.0	25.3	29.6	33.4	35.1	35.2	35.2	35.2	35.2	35.2
H23	23.6	26.9	31.2	34.9	36.7	36.8	36.8	36.8	36.8	36.8
H24	28.9	32.2	36.4	40.2	42.0	42.2	42.2	42.2	42.2	42.2
H25	23.0	26.3	30.6	34.3	36.1	36.2	36.2	36.2	36.2	36.2
H26	29.5	32.8	37.1	40.8	42.7	42.8	42.8	42.8	42.8	42.8
H27	29.0	32.3	36.7	40.4	42.0	42.1	42.1	42.1	42.1	42.1
H28	29.6	32.9	37.2	41.0	42.8	42.9	42.9	42.9	42.9	42.9
H29	29.5	32.8	37.2	40.9	42.6	42.6	42.6	42.6	42.6	42.6
H30	28.2	31.5	35.9	39.6	41.2	41.3	41.3	41.3	41.3	41.3
H31	25.1	28.5	32.9	36.5	38.2	38.3	38.3	38.3	38.3	38.3
H32	21.9	25.3	29.7	33.4	34.9	35.0	35.0	35.0	35.0	35.0

11.10.7 **Table 11.19** shows the margin by which the predicted cumulative operational noise levels the daytime and night-time noise limits set out in **Table 11.13**. A positive number indicates that predicted levels are above the noise limits.

Table 11.19 Cumulative Predicted Margin of Compliance, dB

House ID	Standardised 10 m Height Wind Speed, m.s^{-1}									
	3	4	5	6	7	8	9	10	11	12
DAYTIME										
H1	-16.7	-13.9	-10.4	-7.4	-6.3	-7.1	-8.1	-9.0	-9.9	-10.7
H2	-15.8	-13.0	-9.5	-6.5	-5.5	-6.3	-7.3	-8.2	-9.1	-9.9
H3	-15.5	-12.7	-9.2	-6.2	-5.2	-5.9	-6.9	-7.8	-8.7	-9.5
H4	-11.9	-9.1	-5.6	-2.6	-1.5	-2.3	-3.3	-4.2	-5.1	-5.9
H5	-11.8	-9.0	-5.5	-2.5	-1.4	-2.2	-3.2	-4.1	-5.0	-5.8
H6	-11.3	-8.5	-5.0	-2.0	-0.9	-1.7	-2.7	-3.6	-4.5	-5.3
H7	-12.8	-10.0	-6.5	-3.5	-2.4	-3.2	-4.2	-5.1	-6.0	-6.8
H8	-10.5	-7.7	-4.2	-1.2	-0.2	-1.0	-2.0	-2.9	-3.8	-4.6
H9	-10.3	-7.5	-4.0	-1.0	0.1	-0.7	-1.7	-2.6	-3.5	-4.3
H10	-10.3	-7.5	-4.0	-1.0	0.1	-0.7	-1.7	-2.6	-3.5	-4.3
H11	-12.2	-9.4	-5.9	-2.9	-1.8	-2.6	-3.6	-4.5	-5.4	-6.2
H12	-11.1	-8.3	-4.8	-1.8	-0.7	-1.5	-2.5	-3.4	-4.3	-5.1
H13	-14.7	-12.7	-9.5	-6.3	-5.1	-5.7	-6.6	-8.1	-10.2	-13.1
H14	-14.2	-12.2	-9.0	-5.8	-4.6	-5.2	-6.1	-7.6	-9.7	-12.6
H15	-13.4	-11.3	-8.1	-4.9	-3.7	-4.3	-5.2	-6.7	-8.8	-11.7
H16	-13.8	-11.8	-8.6	-5.4	-4.2	-4.8	-5.7	-7.2	-9.3	-12.2
H17	-14.3	-12.3	-9.0	-5.8	-4.6	-5.2	-6.1	-7.6	-9.7	-12.6
H18	-15.6	-13.6	-10.3	-7.1	-5.9	-6.5	-7.4	-8.9	-11.0	-13.9
H19	-8.7	-6.0	-3.5	-1.8	-1.9	-3.6	-5.2	-6.3	-6.9	-6.9
H20	-16.1	-14.1	-10.8	-7.6	-6.5	-7.1	-8.0	-9.5	-11.6	-14.5
H21	-16.1	-14.1	-10.8	-7.6	-6.5	-7.1	-8.0	-9.5	-11.6	-14.5
H22	-15.4	-13.4	-10.1	-6.9	-5.8	-6.4	-7.3	-8.8	-10.9	-13.8
H23	-16.2	-13.7	-10.0	-6.7	-5.3	-5.6	-6.1	-7.0	-8.2	-9.9
H24	-8.9	-6.3	-2.7	0.4	1.4	0.6	-0.6	-2.1	-3.9	-6.1
H25	-16.8	-14.3	-10.6	-7.3	-5.9	-6.2	-6.7	-7.6	-8.8	-10.5
H26	-8.3	-5.7	-2.0	1.0	2.1	1.2	0.0	-1.5	-3.3	-5.5
H27	-8.8	-6.2	-2.4	0.6	1.4	0.5	-0.7	-2.2	-4.0	-6.2
H28	-8.2	-5.6	-1.9	1.2	2.2	1.3	0.1	-1.4	-3.2	-5.4
H29	-8.3	-5.7	-1.9	1.1	2.0	1.0	-0.2	-1.7	-3.5	-5.7
H30	-9.6	-7.0	-3.2	-0.2	0.6	-0.3	-1.5	-3.0	-4.8	-7.0

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
H31	-12.7	-10.0	-6.2	-3.3	-2.4	-3.3	-4.5	-6.0	-7.8	-10.0
H32	-15.9	-13.2	-9.4	-6.4	-5.7	-6.6	-7.8	-9.3	-11.1	-13.3
NIGHT-TIME										
H1	-23.7	-20.4	-16.2	-12.4	-10.5	-10.4	-10.4	-10.4	-10.4	-10.4
H2	-22.8	-19.5	-15.3	-11.5	-9.7	-9.6	-9.6	-9.6	-9.6	-9.6
H3	-22.5	-19.2	-15.0	-11.2	-9.4	-9.2	-9.2	-9.2	-9.2	-9.2
H4	-18.9	-15.6	-11.4	-7.6	-5.7	-5.6	-5.6	-5.6	-5.6	-5.6
H5	-18.8	-15.5	-11.3	-7.5	-5.6	-5.5	-5.5	-5.5	-5.5	-5.5
H6	-18.3	-15.0	-10.8	-7.0	-5.1	-5.0	-5.0	-5.0	-5.0	-5.0
H7	-19.8	-16.5	-12.3	-8.5	-6.6	-6.5	-6.5	-6.5	-6.5	-6.5
H8	-17.5	-14.2	-10.0	-6.2	-4.4	-4.3	-4.3	-4.3	-4.3	-4.3
H9	-17.3	-14.0	-9.8	-6.0	-4.1	-4.0	-4.0	-4.0	-4.0	-4.0
H10	-17.3	-14.0	-9.8	-6.0	-4.1	-4.0	-4.0	-4.0	-4.0	-4.0
H11	-19.2	-15.9	-11.7	-7.9	-6.0	-5.9	-5.9	-5.9	-5.9	-5.9
H12	-18.1	-14.8	-10.6	-6.8	-4.9	-4.8	-4.8	-4.8	-4.8	-4.8
H13	-20.3	-17.0	-12.8	-9.0	-7.2	-7.1	-7.1	-7.1	-9.5	-9.5
H14	-19.8	-16.5	-12.3	-8.5	-6.7	-6.6	-6.6	-6.6	-9.0	-9.0
H15	-19.0	-15.6	-11.4	-7.6	-5.8	-5.7	-5.7	-5.7	-8.1	-8.1
H16	-19.4	-16.1	-11.9	-8.1	-6.3	-6.2	-6.2	-6.2	-8.6	-8.6
H17	-19.9	-16.6	-12.3	-8.5	-6.7	-6.6	-6.6	-6.6	-9.0	-9.0
H18	-21.2	-17.9	-13.6	-9.8	-8.0	-7.9	-7.9	-7.9	-10.3	-10.3
H19	-16.7	-13.5	-9.2	-5.5	-3.6	-3.4	-3.4	-4.8	-7.2	-9.4
H20	-21.7	-18.4	-14.1	-10.3	-8.6	-8.5	-8.5	-8.5	-10.9	-10.9
H21	-21.7	-18.4	-14.1	-10.3	-8.6	-8.5	-8.5	-8.5	-10.9	-10.9
H22	-21.0	-17.7	-13.4	-9.6	-7.9	-7.8	-7.8	-7.8	-10.2	-10.2
H23	-19.4	-16.1	-11.8	-8.1	-6.3	-6.8	-7.3	-7.7	-8.0	-8.2
H24	-14.1	-10.8	-6.6	-2.8	-1.0	-0.8	-0.8	-0.8	-1.6	-4.4
H25	-20.0	-16.7	-12.4	-8.7	-6.9	-7.4	-7.9	-8.3	-8.6	-8.8
H26	-13.5	-10.2	-5.9	-2.2	-0.3	-0.2	-0.2	-0.2	-1.0	-3.8
H27	-14.0	-10.7	-6.3	-2.6	-1.0	-0.9	-0.9	-0.9	-1.7	-4.5
H28	-13.4	-10.1	-5.8	-2.0	-0.2	-0.1	-0.1	-0.1	-0.9	-3.7
H29	-13.5	-10.2	-5.8	-2.1	-0.4	-0.4	-0.4	-0.4	-1.2	-4.0
H30	-14.8	-11.5	-7.1	-3.4	-1.8	-1.7	-1.7	-1.7	-2.5	-5.3
H31	-17.9	-14.5	-10.1	-6.5	-4.8	-4.7	-4.7	-4.7	-5.5	-8.3
H32	-21.1	-17.7	-13.3	-9.6	-8.1	-8.0	-8.0	-8.0	-8.8	-11.6

11.10.8 The results indicate that the predicted cumulative operational noise levels are up to 2.2 dB above the applied daytime noise limits for standardised 10 m height wind speeds of around 6 to 8 $m.s^{-1}$ at H9, H10, H24, H26, H27, H28, H29 and H30. Similarly, as discussed as part of the isolative assessment for the proposed wind farm presented in **Section 11.7,** this would only occur for a limited range of standardised 10 m height wind speeds and directions, albeit, for a greater proportion of the time and at more properties than for the isolative case. Furthermore, the slight predicted exceedance at H9 & H10 is not considered significant.

11.10.9 As a result of the above, a mechanism is proposed to control the operational noise levels from the proposed wind farm and the cumulative sites considered here via the imposition of apportioned operational noise limits such that the overall requirements of ETSU-R-97 are, as far as possible, met. The apportionment of the limits considers the relative generating capacity of each site and the proximity to neighbouring properties with a view to enabling all three sites to operate in a viable manner and the maximisation of the combined generating capacity of the developments. This approach is intended to form the basis of discussions with the developers of the neighbouring wind farms and the Local Planning Authority (LPA) and is by no means finalised; there are many different approaches which may be taken in this respect. The finalised approach would depend on the evolving design of the cumulative schemes; the results of further background noise surveys in the area (as undertaken by the respective developers); whether certain properties can be considered as financially involved with a particular development; ongoing discussions and negotiations between the developers

and LPA; whether it is considered appropriate to set limits in relation to wind direction as well as wind speed; and other planning constraints amongst other factors.

11.10.10 The initial assessment of the operational noise levels resulting from the proposed wind farm operating in isolation (see **Section 11.7**) indicates that mitigation measures, in the form of curtailment of the turbines (see Section **11.8**), would be required to meet the overall requirements of ETSU-R-97. As a result, it could be considered that the proposed wind farm would already use the entirety of the 'noise budget' at critical properties for certain wind speeds and directions under these circumstances.

11.10.11 The properties that are regarded as critical and considered most affected by the combined operation of the cumulative developments considered here are located to the west and north of the proposed wind farm (H19, H24, H26, H27, H28, H29, H30, H31 and H32).

11.10.12 In order to allow for the Trecelyn Wind Farm and Mynydd Llanhilleth Wind Farm sites to operate in a way that is less restrictive than could otherwise be the case, the operational noise limits for the proposed Mynydd Maen Wind Farm at H24, H26, H27, H28, H29, H30, H31 and H32 are nominally proposed to be set 1 dB lower than the overall ETSU-R-97 limits such that some headroom or remaining 'noise budget' is available for the other developments. The proposed Mynydd Maen site has the largest potential generating capacity of the sites considered here, is relatively close in proximity to these critical dwellings and would have the most impact during the prevailing wind conditions at the site. As a result, it is considered appropriate that the proposed wind farm should garner the highest proportion of the 'noise budget' in these instances. The noise limit for H19 is proposed to be set 4 dB below the overall ETSU-R-97 limit for this location as this residence is located further from the proposed wind farm and has predicted operational noise levels that are similar to that expected from the proposed Trecelyn Wind Farm site.

11.10.13 The remaining properties have predicted operational noise levels from the Trecelyn Wind Farm and/or Mynydd Llanhilleth Wind Farm developments that would be considered negligible in the context of noise from the proposed wind farm, or, have very little risk of overall cumulative operational noise levels being above the overall ETSU-R-97 limits. As a result, the full extent of the derived ETSU-R-97 noise limits have been applied in these instances.

11.10.14 The resultant noise limits, specifically for the proposed wind farm, should the proposed Trecelyn Wind Farm and/or Mynydd Llanhilleth Wind Farm development be granted planning consent, are shown in **Table 11.20**. If the other developments do not obtain planning permission, then the full extent of the ETSU-R-97 limits shown in **Table 11.13** should apply to the proposed wind farm.

Table 11.20 Mynydd Maen Wind Farm Proposed Apportioned Noise Limits, dB L_{A90}

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
DAYTIME										
H1	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H2	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H3	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H4	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H5	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H6	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H7	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H8	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H9	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H10	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H11	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H12	36.0	36.5	37.2	38.0	38.8	39.7	40.7	41.6	42.5	43.3
H13	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H14	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H15	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H16	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
H17	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H18	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H19	31.0	31.5	33.3	35.3	37.3	39.2	40.8	41.9	42.5	42.5
H20	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H21	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H22	37.4	38.7	39.7	40.3	40.9	41.6	42.5	44.0	46.1	49.0
H23	39.8	40.6	41.2	41.6	42.0	42.4	42.9	43.8	45.0	46.7
H24	36.8	37.5	38.1	38.8	39.6	40.6	41.8	43.3	45.1	47.3
H25	39.8	40.6	41.2	41.6	42.0	42.4	42.9	43.8	45.0	46.7
H26	36.8	37.5	38.1	38.8	39.6	40.6	41.8	43.3	45.1	47.3
H27	36.8	37.5	38.1	38.8	39.6	40.6	41.8	43.3	45.1	47.3
H28	36.8	37.5	38.1	38.8	39.6	40.6	41.8	43.3	45.1	47.3
H29	36.8	37.5	38.1	38.8	39.6	40.6	41.8	43.3	45.1	47.3
H30	36.8	37.5	38.1	38.8	39.6	40.6	41.8	43.3	45.1	47.3
H31	36.8	37.5	38.1	38.8	39.6	40.6	41.8	43.3	45.1	47.3
H32	36.8	37.5	38.1	38.8	39.6	40.6	41.8	43.3	45.1	47.3
NIGHT-TIME										
H1	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H2	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H3	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H5	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H7	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H8	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H9	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H10	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H11	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H12	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H13	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H14	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H15	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H16	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H17	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H18	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H19	39.0	39.0	39.0	39.0	39.0	39.0	39.0	40.4	42.8	45.0
H20	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H21	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H22	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	45.4	45.4
H23	43.0	43.0	43.0	43.0	43.0	43.6	44.1	44.5	44.8	45.0
H24	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.8	45.6
H25	43.0	43.0	43.0	43.0	43.0	43.6	44.1	44.5	44.8	45.0
H26	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.8	45.6
H27	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.8	45.6
H28	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.8	45.6
H29	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.8	45.6
H30	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.8	45.6
H31	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.8	45.6
H32	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.8	45.6

11.10.15 The proposed operational noise limits for the Trecelyn Wind Farm and Mynydd Llanhilleth Wind Farm schemes have been apportioned by various nominal amounts depending on factors including the proximity of each site to the various dwellings considered here and the remaining 'noise budget' as a result of imposing stricter limits on the proposed wind farm with a view to maximising the potential generating capacity for each development. Only the critical residential locations (H19, H24, H26, H27, H28, H29, H30, H31 and H32) are considered

in respect of these developments as the other dwellings are located sufficiently far away to be considered immaterial in respect of operational noise from these sites.

11.10.16 The resultant limits for Trecelyn Wind Farm and Mynydd Llanhilleth Wind Farm are shown in **Table 11.21** and **Table 11.22** respectively.

Table 11.21 Trecelyn Wind Farm Proposed Apportioned Noise Limits, dB L_{A90}

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
DAYTIME										
H19	33.0	33.5	35.3	37.3	39.3	41.2	42.8	43.9	44.5	44.5
H24	31.3	32.0	32.6	33.3	34.1	35.1	36.3	37.8	39.6	41.8
H26	28.3	29.0	29.6	30.3	31.1	32.1	33.3	34.8	36.6	38.8
H27	28.3	29.0	29.6	30.3	31.1	32.1	33.3	34.8	36.6	38.8
H28	28.3	29.0	29.6	30.3	31.1	32.1	33.3	34.8	36.6	38.8
H29	27.3	28.0	28.6	29.3	30.1	31.1	32.3	33.8	35.6	37.8
H30	27.3	28.0	28.6	29.3	30.1	31.1	32.3	33.8	35.6	37.8
H31	27.3	28.0	28.6	29.3	30.1	31.1	32.3	33.8	35.6	37.8
H32	27.3	28.0	28.6	29.3	30.1	31.1	32.3	33.8	35.6	37.8
NIGHT-TIME										
H19	41.0	41.0	41.0	41.0	41.0	41.0	41.0	42.4	44.8	47.0
H24	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	37.3	40.1
H26	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	34.3	37.1
H27	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	34.3	37.1
H28	33.5	33.5	33.5	33.5	33.5	33.5	33.5	33.5	34.3	37.1
H29	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	33.3	36.1
H30	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	33.3	36.1
H31	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	33.3	36.1
H32	32.5	32.5	32.5	32.5	32.5	32.5	32.5	32.5	33.3	36.1

Table 11.21 Mynydd Llanhilleth Wind Farm Proposed Apportioned Noise Limits, dB L_{A90}

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
DAYTIME										
H19	25.5	26.0	27.8	29.8	31.8	33.7	35.3	36.4	37.0	37.0
H24	29.3	30.0	30.6	31.3	32.1	33.1	34.3	35.8	37.6	39.8
H26	31.3	32.0	32.6	33.3	34.1	35.1	36.3	37.8	39.6	41.8
H27	31.3	32.0	32.6	33.3	34.1	35.1	36.3	37.8	39.6	41.8
H28	31.3	32.0	32.6	33.3	34.1	35.1	36.3	37.8	39.6	41.8
H29	32.3	33.0	33.6	34.3	35.1	36.1	37.3	38.8	40.6	42.8
H30	32.3	33.0	33.6	34.3	35.1	36.1	37.3	38.8	40.6	42.8
H31	32.3	33.0	33.6	34.3	35.1	36.1	37.3	38.8	40.6	42.8
H32	32.3	33.0	33.6	34.3	35.1	36.1	37.3	38.8	40.6	42.8
NIGHT-TIME										
H19	33.5	33.5	33.5	33.5	33.5	33.5	33.5	34.9	37.3	39.5
H24	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	35.3	38.1
H26	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	37.3	40.1
H27	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	37.3	40.1
H28	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	37.3	40.1
H29	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	38.3	41.1
H30	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	38.3	41.1
H31	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	38.3	41.1
H32	37.5	37.5	37.5	37.5	37.5	37.5	37.5	37.5	38.3	41.1

11.10.17 The operators of the cumulative developments may be required to implement operational noise curtailment strategies in order to meet the limits proposed here if the finalised turbine locations and candidate turbine model for each site are the same or similar to those indicated for scoping purposes. However, the strategies are unlikely to have a substantial impact on the generating capacity for each in-so-far as to make the sites unviable.

11.10.18 The apportioned limits do have the potential to allow very marginal breaches (i.e. a fraction of a dB) over the overall ETSU-R-97 noise limits at some locations, as is often the case when considering the cumulative operational noise impacts from wind farm developments. However, the instances for which this could occur in practice are few when considering the effects of wind direction on the cumulative noise levels and unlikely to occur in reality due to the typical levels of uncertainty incorporated into wind farm operational noise models.

11.10.19 In order to demonstrate the effect of the proposed apportioned noise limits on the predicted cumulative noise levels, in relation to the overall ETSU-R-97 limits shown in **Table 11.13**, a further curtailment strategy (see **Technical Appendix 11.6**) has been determined for the proposed wind farm which includes for the adoption of the relevant apportioned noise limits (see Table **11.20**). The derived curtailment strategy uses the same assumptions referenced in **Section 11.8**.

11.10.20 Further to the above, the predicted noise levels for the Trecelyn Wind Farm and Mynydd Llanhilleth Wind Farm developments have been corrected to account for the proposed apportioned noise limits for each site respectively (see **Tables 11.21 & 11.22**) by restricting the predicted operational noise levels to the proposed limiting values in instances where they are predicted to be above these (i.e. the use of the predicted noise levels or the limiting requirements, whichever is lower, in the assessment). Essentially, this approach incorporates the probable/approximate effect of operational noise curtailment at the Trecelyn Wind Farm and Mynydd Llanhilleth Wind Farm developments without going into the exact specifics of how this would be achieved in practice as this would be a matter for the other developers/operators. In reality, the resulting operational noise levels would also be limited by the presence of 'controlling properties' (i.e. dwellings, often located closest to a particular development or considered most sensitive/critical to noise, which would have the effect of limiting operational noise levels at other properties). As a result, overall levels would be expected to be lower in instances where this effect could occur. The resultant maximum cumulative operational noise levels and corresponding margins of compliance for any given wind direction are shown in **Table 11.22** and **Table 11.23** respectively.

Table 11.22 Cumulative Operational Noise Levels with Limiting Conditions, dB L_{A90}

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
DAYTIME										
H1	19.3	22.6	26.8	30.6	32.5	32.6	32.6	32.6	32.6	32.6
H2	20.2	23.5	27.7	31.5	33.3	33.4	33.4	33.4	33.4	33.4
H3	20.5	23.8	28.0	31.8	33.6	33.8	33.8	33.8	33.8	33.8
H4	24.1	27.4	31.6	35.4	37.3	37.4	37.4	37.4	37.4	37.4
H5	24.2	27.5	31.7	35.5	37.4	37.5	37.5	37.5	37.5	37.5
H6	24.7	28.0	32.2	36.0	37.9	38.0	38.0	38.0	38.0	38.0
H7	23.2	26.5	30.7	34.5	36.4	36.5	36.5	36.5	36.5	36.5
H8	25.5	28.8	33.0	36.8	38.6	38.7	38.7	38.7	38.7	38.7
H9	25.7	29.0	33.2	37.0	38.9	39.0	39.0	39.0	39.0	39.0
H10	25.7	29.0	33.2	37.0	38.9	39.0	39.0	39.0	39.0	39.0
H11	23.8	27.1	31.3	35.1	37.0	37.1	37.1	37.1	37.1	37.1
H12	24.9	28.2	32.4	36.2	38.1	38.2	38.2	38.2	38.2	38.2
H13	22.7	26.0	30.2	34.0	35.8	35.9	35.9	35.9	35.9	35.9
H14	23.2	26.5	30.7	34.5	36.3	36.4	36.4	36.4	36.4	36.4
H15	24.0	27.4	31.6	35.4	37.2	37.3	37.3	37.3	37.3	37.3
H16	23.6	26.9	31.1	34.9	36.7	36.8	36.8	36.8	36.8	36.8
H17	23.1	26.4	30.7	34.5	36.3	36.4	36.4	36.4	36.4	36.4
H18	21.8	25.1	29.4	33.2	35.0	35.1	35.1	35.1	35.1	35.1
H19	26.3	29.5	33.8	37.3	38.9	39.2	39.5	39.6	39.6	39.6
H20	21.3	24.6	28.9	32.7	34.4	34.5	34.5	34.5	34.5	34.5
H21	21.3	24.6	28.9	32.7	34.4	34.5	34.5	34.5	34.5	34.5
H22	22.0	25.3	29.6	33.4	35.1	35.2	35.2	35.2	35.2	35.2
H23	23.6	26.9	31.2	34.9	36.7	36.8	36.8	36.8	36.8	36.8
H24	28.9	32.2	36.4	39.7	40.9	41.7	41.8	42.2	42.2	42.2

House ID	Standardised 10 m Height Wind Speed, m.s^{-1}									
	3	4	5	6	7	8	9	10	11	12
H25	23.0	26.3	30.6	34.3	36.1	36.2	36.2	36.2	36.2	36.2
H26	29.5	32.8	37.1	39.6	40.5	41.3	42.2	42.8	42.8	42.8
H27	29.0	32.3	36.7	39.1	40.1	41.0	41.8	42.1	42.1	42.1
H28	29.6	32.9	37.2	39.7	40.7	41.4	42.2	42.9	42.9	42.9
H29	29.5	32.8	37.2	40.1	41.1	41.9	42.6	42.6	42.6	42.6
H30	28.2	31.5	35.9	39.3	40.4	40.9	41.3	41.3	41.3	41.3
H31	25.1	28.5	32.9	36.4	38.0	38.1	38.3	38.3	38.3	38.3
H32	21.9	25.3	29.7	33.4	34.9	35.0	35.0	35.0	35.0	35.0
NIGHT-TIME										
H1	19.3	22.6	26.8	30.6	32.5	32.6	32.6	32.6	32.6	32.6
H2	20.2	23.5	27.7	31.5	33.3	33.4	33.4	33.4	33.4	33.4
H3	20.5	23.8	28.0	31.8	33.6	33.8	33.8	33.8	33.8	33.8
H4	24.1	27.4	31.6	35.4	37.3	37.4	37.4	37.4	37.4	37.4
H5	24.2	27.5	31.7	35.5	37.4	37.5	37.5	37.5	37.5	37.5
H6	24.7	28.0	32.2	36.0	37.9	38.0	38.0	38.0	38.0	38.0
H7	23.2	26.5	30.7	34.5	36.4	36.5	36.5	36.5	36.5	36.5
H8	25.5	28.8	33.0	36.8	38.6	38.7	38.7	38.7	38.7	38.7
H9	25.7	29.0	33.2	37.0	38.9	39.0	39.0	39.0	39.0	39.0
H10	25.7	29.0	33.2	37.0	38.9	39.0	39.0	39.0	39.0	39.0
H11	23.8	27.1	31.3	35.1	37.0	37.1	37.1	37.1	37.1	37.1
H12	24.9	28.2	32.4	36.2	38.1	38.2	38.2	38.2	38.2	38.2
H13	22.7	26.0	30.2	34.0	35.8	35.9	35.9	35.9	35.9	35.9
H14	23.2	26.5	30.7	34.5	36.3	36.4	36.4	36.4	36.4	36.4
H15	24.0	27.4	31.6	35.4	37.2	37.3	37.3	37.3	37.3	37.3
H16	23.6	26.9	31.1	34.9	36.7	36.8	36.8	36.8	36.8	36.8
H17	23.1	26.4	30.7	34.5	36.3	36.4	36.4	36.4	36.4	36.4
H18	21.8	25.1	29.4	33.2	35.0	35.1	35.1	35.1	35.1	35.1
H19	26.3	29.5	33.8	37.5	39.3	39.5	39.6	39.6	39.6	39.6
H20	21.3	24.6	28.9	32.7	34.4	34.5	34.5	34.5	34.5	34.5
H21	21.3	24.6	28.9	32.7	34.4	34.5	34.5	34.5	34.5	34.5
H22	22.0	25.3	29.6	33.4	35.1	35.2	35.2	35.2	35.2	35.2
H23	23.6	26.9	31.2	34.9	36.7	36.8	36.8	36.8	36.8	36.8
H24	28.9	32.2	36.4	40.2	41.9	41.9	42.0	42.0	42.2	42.2
H25	23.0	26.3	30.6	34.3	36.1	36.2	36.2	36.2	36.2	36.2
H26	29.5	32.8	37.1	40.8	42.3	42.4	42.4	42.4	42.8	42.8
H27	29.0	32.3	36.7	40.4	41.9	41.9	41.9	41.9	42.1	42.1
H28	29.6	32.9	37.2	41.0	42.4	42.4	42.5	42.5	42.9	42.9
H29	29.5	32.8	37.2	40.9	42.5	42.6	42.6	42.6	42.6	42.6
H30	28.2	31.5	35.9	39.6	41.2	41.3	41.3	41.3	41.3	41.3
H31	25.1	28.5	32.9	36.5	38.2	38.3	38.3	38.3	38.3	38.3
H32	21.9	25.3	29.7	33.4	34.9	35.0	35.0	35.0	35.0	35.0

Table 11.23 Minimum Margin of Compliance Incorporating Limiting Conditions, dB

House ID	Standardised 10 m Height Wind Speed, m.s^{-1}									
	3	4	5	6	7	8	9	10	11	12
DAYTIME										
H1	-16.7	-13.9	-10.4	-7.4	-6.3	-7.1	-8.1	-9.0	-9.9	-10.7
H2	-15.8	-13.0	-9.5	-6.5	-5.5	-6.3	-7.3	-8.2	-9.1	-9.9
H3	-15.5	-12.7	-9.2	-6.2	-5.2	-5.9	-6.9	-7.8	-8.7	-9.5
H4	-11.9	-9.1	-5.6	-2.6	-1.5	-2.3	-3.3	-4.2	-5.1	-5.9
H5	-11.8	-9.0	-5.5	-2.5	-1.4	-2.2	-3.2	-4.1	-5.0	-5.8
H6	-11.3	-8.5	-5.0	-2.0	-0.9	-1.7	-2.7	-3.6	-4.5	-5.3
H7	-12.8	-10.0	-6.5	-3.5	-2.4	-3.2	-4.2	-5.1	-6.0	-6.8
H8	-10.5	-7.7	-4.2	-1.2	-0.2	-1.0	-2.0	-2.9	-3.8	-4.6
H9	-10.3	-7.5	-4.0	-1.0	0.1	-0.7	-1.7	-2.6	-3.5	-4.3

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
H10	-10.3	-7.5	-4.0	-1.0	0.1	-0.7	-1.7	-2.6	-3.5	-4.3
H11	-12.2	-9.4	-5.9	-2.9	-1.8	-2.6	-3.6	-4.5	-5.4	-6.2
H12	-11.1	-8.3	-4.8	-1.8	-0.7	-1.5	-2.5	-3.4	-4.3	-5.1
H13	-14.7	-12.7	-9.5	-6.3	-5.1	-5.7	-6.6	-8.1	-10.2	-13.1
H14	-14.2	-12.2	-9.0	-5.8	-4.6	-5.2	-6.1	-7.6	-9.7	-12.6
H15	-13.4	-11.3	-8.1	-4.9	-3.7	-4.3	-5.2	-6.7	-8.8	-11.7
H16	-13.8	-11.8	-8.6	-5.4	-4.2	-4.8	-5.7	-7.2	-9.3	-12.2
H17	-14.3	-12.3	-9.0	-5.8	-4.6	-5.2	-6.1	-7.6	-9.7	-12.6
H18	-15.6	-13.6	-10.3	-7.1	-5.9	-6.5	-7.4	-8.9	-11.0	-13.9
H19	-8.7	-6.0	-3.5	-2.0	-2.4	-4.0	-5.3	-6.3	-6.9	-6.9
H20	-16.1	-14.1	-10.8	-7.6	-6.5	-7.1	-8.0	-9.5	-11.6	-14.5
H21	-16.1	-14.1	-10.8	-7.6	-6.5	-7.1	-8.0	-9.5	-11.6	-14.5
H22	-15.4	-13.4	-10.1	-6.9	-5.8	-6.4	-7.3	-8.8	-10.9	-13.8
H23	-16.2	-13.7	-10.0	-6.7	-5.3	-5.6	-6.1	-7.0	-8.2	-9.9
H24	-8.9	-6.3	-2.7	-0.1	0.3	0.1	-1.0	-2.1	-3.9	-6.1
H25	-16.8	-14.3	-10.6	-7.3	-5.9	-6.2	-6.7	-7.6	-8.8	-10.5
H26	-8.3	-5.7	-2.0	-0.2	-0.1	-0.3	-0.6	-1.5	-3.3	-5.5
H27	-8.8	-6.2	-2.4	-0.7	-0.5	-0.6	-1.0	-2.2	-4.0	-6.2
H28	-8.2	-5.6	-1.9	-0.1	0.1	-0.2	-0.6	-1.4	-3.2	-5.4
H29	-8.3	-5.7	-1.9	0.3	0.5	0.3	-0.2	-1.7	-3.5	-5.7
H30	-9.6	-7.0	-3.2	-0.5	-0.2	-0.7	-1.5	-3.0	-4.8	-7.0
H31	-12.7	-10.0	-6.2	-3.4	-2.6	-3.5	-4.5	-6.0	-7.8	-10.0
H32	-15.9	-13.2	-9.4	-6.4	-5.7	-6.6	-7.8	-9.3	-11.1	-13.3
NIGHT-TIME										
H1	-23.7	-20.4	-16.2	-12.4	-10.5	-10.4	-10.4	-10.4	-10.4	-10.4
H2	-22.8	-19.5	-15.3	-11.5	-9.7	-9.6	-9.6	-9.6	-9.6	-9.6
H3	-22.5	-19.2	-15.0	-11.2	-9.4	-9.2	-9.2	-9.2	-9.2	-9.2
H4	-18.9	-15.6	-11.4	-7.6	-5.7	-5.6	-5.6	-5.6	-5.6	-5.6
H5	-18.8	-15.5	-11.3	-7.5	-5.6	-5.5	-5.5	-5.5	-5.5	-5.5
H6	-18.3	-15.0	-10.8	-7.0	-5.1	-5.0	-5.0	-5.0	-5.0	-5.0
H7	-19.8	-16.5	-12.3	-8.5	-6.6	-6.5	-6.5	-6.5	-6.5	-6.5
H8	-17.5	-14.2	-10.0	-6.2	-4.4	-4.3	-4.3	-4.3	-4.3	-4.3
H9	-17.3	-14.0	-9.8	-6.0	-4.1	-4.0	-4.0	-4.0	-4.0	-4.0
H10	-17.3	-14.0	-9.8	-6.0	-4.1	-4.0	-4.0	-4.0	-4.0	-4.0
H11	-19.2	-15.9	-11.7	-7.9	-6.0	-5.9	-5.9	-5.9	-5.9	-5.9
H12	-18.1	-14.8	-10.6	-6.8	-4.9	-4.8	-4.8	-4.8	-4.8	-4.8
H13	-20.3	-17.0	-12.8	-9.0	-7.2	-7.1	-7.1	-7.1	-9.5	-9.5
H14	-19.8	-16.5	-12.3	-8.5	-6.7	-6.6	-6.6	-6.6	-9.0	-9.0
H15	-19.0	-15.6	-11.4	-7.6	-5.8	-5.7	-5.7	-5.7	-8.1	-8.1
H16	-19.4	-16.1	-11.9	-8.1	-6.3	-6.2	-6.2	-6.2	-8.6	-8.6
H17	-19.9	-16.6	-12.3	-8.5	-6.7	-6.6	-6.6	-6.6	-9.0	-9.0
H18	-21.2	-17.9	-13.6	-9.8	-8.0	-7.9	-7.9	-7.9	-10.3	-10.3
H19	-16.7	-13.5	-9.2	-5.5	-3.7	-3.5	-3.4	-4.8	-7.2	-9.4
H20	-21.7	-18.4	-14.1	-10.3	-8.6	-8.5	-8.5	-8.5	-10.9	-10.9
H21	-21.7	-18.4	-14.1	-10.3	-8.6	-8.5	-8.5	-8.5	-10.9	-10.9
H22	-21.0	-17.7	-13.4	-9.6	-7.9	-7.8	-7.8	-7.8	-10.2	-10.2
H23	-19.4	-16.1	-11.8	-8.1	-6.3	-6.8	-7.3	-7.7	-8.0	-8.2
H24	-14.1	-10.8	-6.6	-2.8	-1.1	-1.1	-1.0	-1.0	-1.6	-4.4
H25	-20.0	-16.7	-12.4	-8.7	-6.9	-7.4	-7.9	-8.3	-8.6	-8.8
H26	-13.5	-10.2	-5.9	-2.2	-0.7	-0.6	-0.6	-0.6	-1.0	-3.8
H27	-14.0	-10.7	-6.3	-2.6	-1.1	-1.1	-1.1	-1.1	-1.7	-4.5
H28	-13.4	-10.1	-5.8	-2.0	-0.6	-0.6	-0.5	-0.5	-0.9	-3.7
H29	-13.5	-10.2	-5.8	-2.1	-0.5	-0.4	-0.4	-0.4	-1.2	-4.0
H30	-14.8	-11.5	-7.1	-3.4	-1.8	-1.7	-1.7	-1.7	-2.5	-5.3
H31	-17.9	-14.5	-10.1	-6.5	-4.8	-4.7	-4.7	-4.7	-5.5	-8.3

House ID	Standardised 10 m Height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
H32	-21.1	-17.7	-13.3	-9.6	-8.1	-8.0	-8.0	-8.0	-8.8	-11.6

11.10.21 The results demonstrate that, notwithstanding the instances where expected noise levels could be very marginally above the overall cumulative noise limits prescribed by ETSU-R-97 as discussed earlier and by a fraction of a dB, the overall combined noise levels meet the cumulative noise limits for all wind speeds and directions for both daytime and night-time periods. As a result, the effects associated with the cumulative assessment are considered not significant.

Construction Noise & Vibration

11.10.22 Noise due to the construction of the other wind farms considered in the cumulative operational noise assessment is unlikely to be present at the same time as the construction of the proposed wind farm. However, if construction activities are undertaken concurrently this would generally amount to an increase in the frequency of traffic (including HGVs) entering the various sites and passing local residences as a result; an increase in the number of blasting events (if borrow pits are to be proposed as part of the cumulative wind farm schemes); and a slight increase in the overall construction noise levels when building out the infrastructure at each site. As a result, a detailed assessment has not been undertaken and the effect is considered not significant provided that all usual controls and best practice is followed in terms of construction techniques.

11.11 Summary

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

11.11.2 To establish baseline conditions, background noise surveys were carried out at five nearby properties and the measured background noise levels used to determine appropriate noise limits as specified by ETSU-R-97 and the IOA GPG.

11.11.3 Operational noise levels were predicted using a noise propagation model, the proposed turbine locations, terrain data and assumed turbine emission data. The assessment has demonstrated that it is possible to meet noise limits derived in accordance with ETSU-R-97 at all properties at all considered wind speeds when the proposed wind farm is considered on its own provided that an appropriate operational noise mitigation strategy is put in place.

11.11.4 Construction noise levels are expected to be below construction noise criteria. Nevertheless, best practicable means would be used to reduce construction noise levels as far as is reasonably practicable and reasonable, particularly in instances where local residences are located close to access tracks and any areas for which works to improve access is required.

11.11.5 The level of vibration at nearby properties due to blasting at the proposed borrow pits indicates that the probability of adverse comment or complaint is low due to the relative distance of the borrow pits to neighbouring dwellings. Regardless, best practicable means to reduce the level of noise and vibration generated by blasting would be employed, including keeping the local council and residents informed as to planned activities. Vibration and air overpressure due to blasting are not expected to have a significant impact on nearby residents should normal mitigation measures described previously be adopted.

11.11.6 A cumulative operational noise assessment was completed to determine the potential impact of the proposed wind farm in conjunction with two other potential schemes are located nearby. Cumulative noise levels, with appropriate mitigation measures applied to the proposed wind farm and proposed planning controls for each site applied in practice, can meet the overall noise limits derived in accordance with ETSU-R-97 at all properties at all considered wind speeds, notwithstanding the theoretical instances where overall noise levels are marginally above the limits for certain wind directions, as is often the case when considering cumulative operational noise impacts from wind turbines.

11.11.7 The potential impact of the proposed wind farm, along with the mitigation proposed and any residual impact, is summarised in **Table 11.24**.

Table 11.24 Summary of Impacts, Proposed Mitigation & Residual Impacts

Potential Impact	Mitigation Proposed	Means of Implementation	Outcome/Residual Impact
OPERATION			
Potential for operational noise to exceed daytime limit for isolative and cumulative scenarios.	Noise management to meet daytime limit at wind speeds and direction sectors, where necessary.	Operation of certain turbines in reduced noise mode.	Impact deemed acceptable and not significant as cumulative wind farm noise levels meet limits specified by relevant guidance.
CONSTRUCTION			
Potential for construction noise to be above recommended limits in instances where access track use and upgrades occur in close proximity to certain residences.	Reduce construction noise levels to comply with relevant criteria via 'best practicable means'.	Via implementation of CEMP and keeping residents informed as to potential construction activities.	Impact deemed acceptable and not significant with relevant and typical construction controls put in place.

11.12 References

[1] Welsh Government (February 2021) Future Wales – The National Plan 2040

[2] Welsh Government (February 2021) Planning Policy Wales - Edition 11

[3] Welsh Government (December 2023) Noise and Soundscape Plan for Wales 2023 to 2028

[4] Department for Business, Energy and Industrial Strategy (October 2022) A Review of Noise Guidance for Onshore Wind Turbines

[5] Welsh Government (February 2011) Practice Guidance - Planning Implications of Renewable and Low Carbon Energy

[6] Welsh Government (November 2023) Designing for Renewable Energy in Wales

[7] Welsh Government (October 1997) Planning Guidance - Technical Advice Note 11 – Noise

[8] Welsh Government (November 2015) CL-01-15 Updates to TAN 11 Noise - Noise Action Plan (2013-18) Commitments

[9] Welsh Government (July 2005) Planning Guidance – Technical Advice Note 8 – Planning for Renewable Energy

[10] Department of Trade & Industry (September 1996) ETSU-R-97 The Assessment & Rating of Noise from Wind Farms

[11] Institute of Acoustics (May 2013) A Good Practice Guide to the Assessment & Rating of Noise from Wind Farms

[12] Institute of Acoustics (March 2009) Acoustics Bulletin Vol 34 No 2 - Prediction and Assessment of Wind Turbine Noise

[13] British Standards Institution (February 2014) BS 8233:2014 Guidance on Sound Insulation and Noise Reduction for Buildings

[14] British Standards Institution (February 2014) BS 5228-1:2009 + A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites - Part 1: Noise

[15] British Standards Institution (June 2014) BS 5228-2:2009 + A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites - Part 2: Vibration

[16] British Standards Institution (June 2008) BS 6472-2:2008 Guide to Evaluation of Human Exposure to Vibration in Buildings - Part 2: Blast-induced Vibration

[17] Her Majesty's Stationery Office (July 1974) The Control of Pollution Act (CoPA)

[18] British Standards Institution (June 2019) BS 4142:2014 + A1:2019 Methods for Rating and Assessing Industrial and Commercial Sound

[19] British Standards Institution (1990) BS 4142:1990 Method for Rating Industrial Noise Affecting Mixed Residential and Industrial Areas

[20] International Organisation for Standardisation (December 1996) ISO 9613-2:1996 Acoustics - Attenuation of Sound During Propagation Outdoors - Part 2: General Method of Calculation

[21] Department of Trade and Industry (January 2000) ETSU Report W/13/00385/REP - A Critical Appraisal of Wind Farm Noise Propagation

[22] International Organisation for Standardisation (June 1993) Acoustics - Attenuation of Sound During Propagation Outdoors - Part 1: Calculation of the absorption of sound by the atmosphere

[23] J H Bass, A J Bullmore, E Sloth (May 1998) JOR3-CT95-0051 - Development of a Wind Farm Noise Propagation Prediction Model

[24] Vestas (September 2018) Performance Specification V117-4.0/4.2 MW 50/60 Hz Strong Wind Document No.: 0067-7063 V05

[25] Vestas (October 2020) Performance Specification V150-4.0/4.2 MW 50/60 Hz Document No.: 0067-7067 V12

[26] Vestas (December 2017) V117-4.0 & 4.2 MW Third Octave Noise Emission (Strong wind & Typhoon) Document No. 0067-7587 V02

[27] Vestas (March 2018) V150-4.0/4.2 MW Third Octave Noise Emission Document No.: 0067-4767 V05

[28] International Electrotechnical Commission (1979) IEC 60651:1979 Sound Level Meters

[29] International Electrotechnical Commission (December 2013) IEC 61672-1:2013 Electroacoustics - Sound Level Meters - Specifications