CHAPTER 7 – NOISE ASSESSMENT

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7 NOISE ASSESSMENT

Introduction

7.1 This chapter includes an assessment of the potential acoustic impact associated with the development of two turbines on the southerly slope of Mynydd Pencarreg in Carmarthenshire, Wales.

7.2 A noise impact assessment has been performed by comparing predicted noise levels produced by the wind turbines and published guidelines relating to wind turbine noise.

7.3 The proposed turbines have also been considered cumulatively with the single turbine south west of Bryn Dafydd currently in planning.

Planning Policy, British Standards and Other Guidance

7.4 Planning Policy dealing with the issue of wind turbines is contained within Planning Policy Wales (Welsh Assembly Government, July 2014), which is addressed in Chapter 2: Planning Policy.

Practice Guidance: Planning Implications of Renewable and Low Carbon Energy Development (February 2011)

7.5 Planning Implications of Renewable and Low Carbon Energy Development (Welsh Assembly Government, February 2011), provides guidance to Local Authorities in determining applications for renewable energy developments. It considers noise within Sections 3.4.6, to 3.4.9 where the following is stated:

> *3.4.6 Wind turbines, either individually, as larger groups or micro-turbines, generate noise from two distinct sources; mechanical noise from the generator and gearbox and aerodynamic noise from the turbine blades as they move through the air. Modern designs have reduced the mechanical noise so that it is now generally less than or at a similar level to the aerodynamic noise. The aerodynamic noise is generally unobtrusive in nature, having been described as similar to the noise of wind in trees. An increase in noise levels at nearby residences can occur during the construction and decommissioning of a wind farm - for*

example from construction activity such as the laying of access tracks, piling and construction or decommissioning of the turbines. Noise levels will be less significant during the construction and decommissioning of an individual wind turbine, as less infrastructure is generally required.

3.4.7 Careful consideration of the siting and layout design of individual turbines/wind farm is important to ensure that increases in ambient noise levels around noise-sensitive development (i.e. residential properties) are kept to acceptable levels in relation to existing background noise. Increases in noise levels can be minimised by ensuring that there is sufficient distance between the turbines and residential properties.

3.4.8 It is important to ensure that predicted operational noise levels fall within the established limits of ETSU-R-97 (The Assessment and Rating of Noise from Wind farms (1997) Energy Technology Support Unit). This guidance sets out indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farms. The levels are set relative to background noise limits, rather than as absolute limits, with separate limits for day-time and night-time. They are presented in a manner that makes them suitable for noise related planning conditions.

3.4.9 Noise impacts resulting from construction and decommissioning activity for large-scale turbines/wind farms can be mitigated by restricting working hours and adopting good practice measures for reducing noise in line with British Standards Guidance (i.e. BS 5228 Noise and Vibration Control on Construction and Open Sites and BS 8233 Sound Insulation and Noise Reductions for Buildings).

National Policy Statement for Renewable Energy Infrastructure (EN-3)

7.6 The National Policy Statement (NPS) for Renewable Energy Infrastructure (EN-3) (Department of Energy and Climate Change, 2011) is the relevant technology specific NPS for the proposed development. EN-3 states in Section 2.7.53 that:

2.7.53 Operational wind turbines will generate increases in noise levels (whether from machinery, e.g. aerodynamic noise from turbines, or from *associated sources, such as traffic) although the relative noise impact diminishes with distance. The noise associated with the construction and decommissioning of the proposed infrastructure, including construction traffic, is covered in EN-1.*

7.7 Further, Section 2.7.56 states:

The applicant's assessment of noise from the operation of the wind turbines should use ETSU-R-97, taking account of the latest industry good practice. This should include any guidance on best practice that the Government may from time to time publish.

7.8 The guidance contained within ETSU-R-97 is addressed in Paragraphs 7.19 - 7.26 below.

Planning Guidance (Wales) Technical Advice Note (Wales) 11: Noise (TAN 11)

7.9 Detailed guidance concerning noise is given within Planning Guidance (Wales) Technical Advice Note (Wales) 11: Noise (TAN 11) (Welsh Assembly Government, October 1997). Specific guidance to the noise issues raised by wind farm developments is given in Annex B Paragraph B19 which states that:

Detailed guidance on noise from wind turbines is contained in Planning Guidance (Wales), Technical Advice Note (Wales) 8, 'Renewable Energy', Welsh Office, 1996, Annex A Paragraphs A28 - A38.

7.10 TAN 8 was revised in July 2005 and detailed guidance is now contained within Annex C of the revised document. The relevant details are given below.

Planning Guidance (Wales) Technical Advice Note (Wales) 8: Renewable Energy

7.11 Planning Guidance (Wales) Technical Advice Note (Wales) 8: Renewable Energy (TAN 8) (Welsh Assembly Government, July 2005) advises at Paragraph 2.14 that:

Well-designed wind farms should be located so that increases in ambient noise levels around noise-sensitive developments are kept to acceptable noise levels with relation to existing background noise. This *will normally be achieved through good design of the turbines and through allowing sufficient distance between the turbines and any existing noise sensitive development. Noise levels are generally low and, under most operating conditions, it is likely that turbine noise would be completely masked by wind-generated background noise.*

7.12 It then goes on to discuss the noise sources found within wind turbines. These may be summarised as follows.

> 1. *Mechanical Noise: generated by the gearbox, generator and other parts of the drive train which can be radiated as noise through the nacelle, gear box and tower supporting structures. Careful design at the development stage of a wind turbine can eradicate this source of noise such that most modern wind turbines do not exhibit tonal noise within the measured/audible noise emissions.*
>
> 2. *Aerodynamic Noise: generated by the action of the rotating blades of the turbine as they pass through the air. The level of noise from the source is determined by the speed of the blades as they pass through the air. This in turn is determined by the rotor diameter and the rate of rotation. Tip designs for blades have improved resulting in reductions in high frequency noise emissions from this source.*

7.13 Paragraph 2.14 then goes on to say that recent turbine designs are quieter than those first installed in Wales. It continues:

Aerodynamic noise from wind turbines is generally unobtrusive - it is broad band in nature and in this respect is similar to, for example, the noise of wind in trees.

7.14 Paragraph 2.15 goes on to indicate that the impact of noise is likely to be greater at low wind speeds, stating that:

Wind-generated background noise increases with wind speed, and at a faster rate than the turbine noise increases. The noise of the wind farm is therefore more likely to be noticeable at low wind speeds. Varying the speed of the turbines in such conditions can, if necessary, reduce the sound output from modern turbines.

7.15 Paragraph 2.16 then directs the reader to a source of detailed information on wind turbine noise which is contained within the document ETSU-R-97 "*The Assessment and Rating of Noise from Wind Farms*", where it is stated that:

> *The report presents the findings from a cross-interest Noise Working Group and makes a series of recommendations that can be regarded as relevant guidance on good practice.*

7.16 Paragraph 2.17 then discusses low frequency noise from wind farms and states that:

> *There is no evidence that ground transmitted low frequency noise from wind turbines is at a sufficient level to be harmful to human health.*

7.17 Paragraph 2.18 then discusses the findings of low frequency noise and vibration studies in the U.K and states that:

> *Vibration levels 100m from the nearest turbine were a factor of ten less than those recommended for human exposure in critical buildings.*

7.18 Measurements were recorded within the report that detail levels of low frequency acoustic energy which fall below recognised perception thresholds for such a noise source. Despite the reference to ground borne noise, the conclusions apply equally to airborne noise.

The Assessment and Rating of Noise from Wind Farms: ETSU-R-97

7.19 ETSU-R-97, The Assessment and Rating of Noise from Wind Farms (ETSU-R-97, 1996), presents the recommendations of the Working Group on Noise from Wind Turbines, set up in 1993 by the Department of Trade and Industry (DTI) as a result of difficulties experienced in applying the noise guidelines existing at the time to wind farm noise assessments. The group comprised independent experts on wind turbine noise, wind farm developers, DTI personnel and local authority Environmental Health Officers. In September 1996 the Working Group published its findings by way of report ETSU-R-97. This document describes a framework for the measurement of wind farm noise and contains suggested noise limits, which were derived with reference to existing standards and guidance relating to noise emission from various sources.

7.20 ETSU-R-97 recommends that, although noise limits should be set relative to existing background and should reflect the variation of both turbine and background noise with wind speed; this can imply very low noise limits in particularly quiet areas, in which case "*it is not necessary to use a margin above background in such low-noise environments. This would be unduly restrictive on developments which are recognised as having wider global benefits. Such low limits are, in any event, not necessary in order to offer a reasonable degree of protection to the wind farm neighbour.*"

7.21 For day-time periods, the noise limit is 35-40 dB L_{A90} or 5 dB(A) above the 'quiet day-time hours' prevailing background noise, whichever is the greater. The actual value within the 35-40 dB(A) range depends on the number of dwellings in the vicinity; the impact of the limit on the number of kWh generated; and the duration of the level of exposure.

7.22 For night-time periods the noise limit is 43 dB L_{A90} or 5 dB(A) above the prevailing night-time hours background noise, whichever is the greater. The 43 dB(A) lower limit is based on an internal sleep disturbance criterion of 35 dB(A) with an allowance of 10 dB(A) for attenuation through an open window and 2 dB(A) subtracted to account for the use of L_{A90} rather the L_{Aeq}.

7.23 Where predicted noise levels are low at the nearest residential properties a simplified noise limit can be applied, such that noise is restricted to the minimum ETSU-R-97 level of 35 dB L_{A90} for wind speeds up to 10 m.s^{-1} at 10 m height. This removes the need for extensive background noise measurements for smaller or more remote schemes.

7.24 It is stated that the $L_{A90,10min}$ noise descriptor should be adopted for both background and wind farm noise levels and that, for the wind farm noise, this is likely to be between 1.5 and 2.5 dB less than the L_{Aeq} measured over the same period. The $L_{Aeq,t}$ is the equivalent continuous 'A' weighted sound pressure level occurring over the measurement period 't'. It is often used as a description of the average ambient noise level. Use of the L_{A90}

descriptor for wind farm noise allows reliable measurements to be made without corruption from relatively loud, transitory noise events from other sources.

7.25 ETSU-R-97 also specifies that a penalty should be added to the predicted noise levels, where any tonal component is present. The level of this penalty is described and is related to the level by which any tonal components exceed the threshold of audibility.

7.26 With regard to multiple wind farms in a given area, ETSU-R-97 specifies that the absolute noise limits and margins above background should relate to the cumulative impact of all wind turbines in the area contributing to the noise received at the properties in question. Existing wind farms should therefore be included in cumulative predictions of noise level for proposed wind turbines and not considered as part of the prevailing background noise.

A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise

7.27 In May 2013, the Institute of Acoustics (IoA) published a Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (Institute of Acoustics, 2013). This was subsequently endorsed by the Secretary of State for Energy and Climate Change and by the Welsh Government (Welsh Assembly Government, n.d.). The publication of the Good Practice Guide (GPG) followed a review of current practice (Department of Energy and Climate Change, 2011) carried out for the Department of Energy and Climate Change (DECC) and an IoA discussion document (Institute of Acoustics, July 2012) which preceded the GPG.

7.28 The GPG includes sections on Context; Background Data Collection; Data Analysis and Noise Limit Derivation; Noise Predictions; Cumulative Issues; Reporting; and Other Matters including Planning Conditions, Amplitude Modulation, Post Completion Measurements and Supplementary Guidance Notes. The Context section states that the guide '*presents current good practice in the application of the ETSU-R-97 assessment* *methodology for all wind turbine development above 50 kW, reflecting the original principles within ETSU-R-97, and the results of research carried out and experience gained since ETSU-R-97 was published*'. It adds that '*the noise limits in ETSU-R-97 have not been examined as these are a matter for Government*'.

7.29 As well as expanding on and, in some areas, clarifying issues which are already referred to in ETSU-R-97, additional guidance is provided on noise prediction and a preferred methodology for dealing with wind shear. The guidance within the GPG has been considered and followed for this assessment.

Noise Impact Assessment Criteria

7.30 ETSU-R-97 indicates that if operational noise from the wind turbines does not exceed a level of 35 dB L_{A90} at any neighbouring dwelling for a wind speed of 10 $m.s^{-1}$, then the simplified method outlined within ETSU-R-97 may be applied. This would indicate that no background noise survey would be required and that operational noise from the wind turbines would be acceptable.

7.31 In the event that operational noise levels exceed the fixed limit of 35 dB L_{A90} for a wind speed of $10m.s^{-1}$ then there may be a need for undertaking background noise level measurements to determine the acceptability of the proposed development.

7.32 To assess the acceptability of the development when operating, wind turbine noise has been assessed in accordance with the guidance contained within ETSU-R-97.

Other Issues in the Assessment of Wind Turbine Noise

Blade Swish (Amplitude Modulation of Aerodynamic Noise)

7.33 The variation in noise level associated with turbine operation, at the rate at which turbine blades pass any fixed point of their rotation (the blade passing frequency), is often referred to as blade swish and amplitude or aerodynamic modulation (AM). This affect is identified within ETSU-R-97 where it is envisaged that '… *modulation of blade noise may result in variation of the overall A-Weighted noise level by as much as 3 dB(A) (peak to trough) when measured close to a wind turbine...* ' and that at distances further from the turbine where there are '… *more than two hard, reflective surfaces, then the increase in modulation depth may be as much as 6 dB(A) (peak to trough)*'. It stated that this effect tends to be associated with trailing edge noise radiated from the outer portion of a turbine blade and is normally centred around the 800-1000 Hz region.

7.34 It has been noted that complaints about wind farm noise have, in many cases, been specifically concerned with amplitude modulation. This is also apparent from ETSU-R-97 where it is noted that '*it is the regular variation of the noise with time that, in some circumstances, enables the listener to distinguish the noise of the turbines from the surrounding noise*'. The modulation of noise may affect perceived annoyance for sounds with the same overall sound pressure level.

7.35 Work carried out in 2006 to investigate the extent of low frequency and infrasonic noise from three UK wind farms (DTI, 2006) concluded that '*the common cause of complaints associated with noise at all three wind farms is not associated with low frequency noise, but is the audible modulation of the aerodynamic noise, especially at night*'. As a result, Salford University carried out a study, jointly commissioned by DEFRA, BERR (formerly the DTI now DECC) and the CLG, to investigate modulation effects which concluded in 2007 (Moorhouse, et al., July 2007) that AM was only considered to be a definite contributing factor in reported complaints at 4, and only a possible factor at a further 8, of the 133 sites operational sites in the UK at the time of the study.

7.36 Further research carried out by various authors since the time of this research has, however, confirmed AM to be an ongoing issue but has identified that where the spectrum of the modulated noise moves from the 800-1000 Hz identified in ETSU-R-97 to lower frequencies, where, the noise is less likely to be masked by higher frequency background noise such as wind in the trees, and the modulated noise increases in depth, perceived effects become more pronounced.

7.37 As a result, Renewable UK, the main renewable energy trade association in the UK, has recently completed research into the causes and subjective effects of these higher levels of AM (RenewableUK, December 2013a; Temple Group, December 2013a; Temple Group, December 2013b; RenewableUK, December 2013b). This has concluded that the predominant cause is likely to be from individual blades going in and out of stall as they pass through regions of higher wind speed at the top of their rotation under high wind shear conditions. Subjective tests carried out by Salford University, using annoyance matching techniques, have demonstrated the extent to which higher levels of modulation depth result in increased perceived annoyance.

Tonal Noise

7.38 ETSU-R-97 notes that, at the time the report was written, where complaints had been made over noise from existing wind farms, the tonal character of the noise from machinery in the nacelle had been the feature that had caused greatest annoyance. The recommendation was, therefore, that any assessment carried out should include a correction to the predicted noise levels according to the level of any tonal components in the noise. A specific tonal assessment methodology is described in the report which is based on the well-established *Joint Nordic Method for the Evaluation of Tones in Broadband Noise* (Delta Acoustics and Vibration, 1999) which has now been superseded by a revised version although this revision makes no substantive difference to the ETSU-R-97 methodology. A scale of corrections for tonal noise is included where the penalty is increased as the tone level increases above audibility to a maximum of 5 dB. The necessity of minimising tonal components in the noise output from the turbines is well understood by the turbine manufacturers and a guarantee should always be sought that any tonal noise will be below that requiring a penalty under the ETSU-R-97 scheme.

Infrasound

7.39 Infra-sound is defined as noise occurring at frequencies below that at which sound is normally audible, i.e. at less than 20 Hz, due to the significantly reduced sensitivity of human hearing at such frequencies. In this frequency range, for sound to be perceptible, it has to be at very high amplitude and it is generally considered that when such sounds are perceptible then they can cause considerable annoyance.

7.40 A considerable amount of research has been conducted in regards to the levels of infrasound that wind turbines emit (e.g. (ETSU, 1997), (Styles, et al., July 2005), (Turnball, et al., April 2012)). All reliable evidence suggests that at typical residential distances (e.g. at 500m or more), the levels of infrasound from a wind farm are below accepted thresholds of perception. Even when measured in close proximity to a wind turbine, the measured levels of infrasound are below accepted thresholds of perception. This suggests that infrasound is not an issue for neighbours in the vicinity of wind turbines.

Low Frequency Noise

7.41 Noise from modern wind turbines is essentially broad band in nature in that it contains similar amounts of noise energy in all frequency bands from low to high frequency. As distance from a wind farm site increases the noise level decreases as a result of the spreading out of the sound energy but also due to air absorption which increases the level of attenuation with increasing frequency. This means that, although the energy across the whole frequency range is reduced, higher frequencies are reduced more than lower frequencies with the effect that as distance from the site increases the ratio of low to high frequencies also increases. This effect may be observed with road traffic noise or natural sources such as the sea where higher frequency components are diminished relative to lower frequency components at long distances. However, this spectral shift is only apparent at large distances from the site when overall noise levels are low. Wind turbines are not a significant source of low frequency or infrasonic noise.

Vibration

7.42 The ETSU study (ETSU, 1997) found that vibration from wind turbines, as measured at 100 m from the nearest machine, was well below the BS6472-

1:2008 (BS 6472-1:2008, 2008) criteria recommended for human exposure in critical working areas such as precision laboratories. At greater distances from turbines vibration levels will be even lower. This has been confirmed in a study by Keele University (Styles, et al., July 2005), which showed vibration levels of around 10^{-8} m.s^{-2} at a distance of 2.4 km from the Dun Law Wind Farm site under high wind conditions, orders of magnitude lower than the criteria referred to above which specify levels in the region of 0.005 m.s^{-2}.

Prediction of Operational Wind Turbine Noise Levels

7.43 Noise predictions have been carried out using International Standard ISO 9613, *Acoustics - Attenuation of Sound during Propagation Outdoors*. The propagation model described in Part 2 (ISO 9613-2:1996, 1996) of this standard provides for the prediction of sound pressure levels based on either short-term downwind (i.e. worst case) conditions or long term overall averages. Only the downwind condition has been assessed, that is, for wind blowing from the proposed site towards the nearby houses. When the wind is blowing in opposite direction noise levels may be significantly lower, especially if there is any shielding between the site and the houses.

7.44 The GPG suggests that ISO 9613-2 can be applied to obtain realistic predictions of noise from on-shore wind turbines during worst case propagations, provided that the appropriate choice of input parameters and correction factors are made. The input parameters utilised in this assessment are described below.

7.45 The ISO propagation model calculates the predicted sound pressure level by taking the source sound power level for each turbine in separate octave bands and subtracting a number of attenuation factors according to the following:

$$\text{Predicted Octave Band Noise Level} = L_W + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc}$$

7.46 These factors are discussed in detail below. The predicted octave band levels from each of the turbines are summed together to give the overall 'A' weighted predicted sound level from all the turbines acting together. A

2dB reduction is assumed between the predicted L_{Aeq} and L_{A90} wind turbine noise level.

L_W – Source Sound Power Level

7.47 The sound power level of a noise source is normally expressed in dB re:1pW. Noise predictions have been based on sound power levels from a candidate turbine, in this case a Senvion MM100 with a hub height of 75m. The noise from this model is typical for turbines of this size. The final turbine choice will be made post-consent following a competitive tendering exercise. Declared sound power levels for the Senvion MM100 have been obtained[1]. The octave band data for the Senvion MM100 turbine is based upon the manufacturer supplied information[2].

7.48 The declared sound power levels with the addition of 1 dB are considered likely to be similar to those which are normally warranted and therefore 1 dB has been added to the source noise levels to account for uncertainty.

7.49 Table 7.1 below details the source sound power levels used in the assessment. A single spectrum at 10 m.s^{-1} has been normalised to each integer wind speed for all stated turbine source sound power levels below.

7.50 For the Senvion MM100 wind turbine, declared sound power levels below 6 m.s^{-1} have been calculated using a trend from the values at integer wind speeds 6 – 9 m.s^{-1}.

Table 7.1: Source Sound Power Level for Senvion MM100 Wind Turbine, 75m hub height

dB(A) re: 10-12 W		Octave Band Centre Frequency (Hz)							
Standardised 10m agl Wind Speed: m.s-1	LWA	63	125	250	500	1k	2k	4k	8k
4	97.1	79.8	85.2	90.8	92.1	91.3	86.5	79.1	65.6
5	102.4	84.0	90.3	95.4	97.6	96.8	91.9	85.9	72.6
6	104.0	85.7	92.2	97.0	99.3	98.3	93.5	87.7	74.8
7	104.7	86.6	92.9	97.6	99.8	99	94.4	89.6	76.3

[1] Power Curve & Sound Power Level [MM100/20000kW/50Hz] Doc. No.: SD-2.21-WT.PC.01-A-G-EN Date: 2016-02-29

[2] Octave & Third Octave Band Data [MM100/50Hz/60Hz] General Information: Doc.-ID: GI-2.21-WT.PO.04-A-A-EN 2014-03-11

dB(A) re: 10-12 W		Octave Band Centre Frequency (Hz)							
Standardised 10m agl Wind Speed: m.s-1	LWA	63	125	250	500	1k	2k	4k	8k
8	104.8	87.3	93.1	97.0	99.6	99.4	95.2	90.6	77.3
9	104.8	86.6	92.8	97.1	99.6	99.4	95.2	90.6	77.3
10	104.8	87.6	93.1	96.5	99.2	99.5	96	92.3	77.7

7.51 No allowance has been made for the character of the noise emitted by the wind turbines. The noise specification for the wind turbine sets out a maximum tone audibility of $L_{A,K}$ < 0 dB, i.e. no audible tones when assessed in accordance within the method set out within BS EN 61400-11.

D – Directivity Factor

7.52 The directivity factor allows for an adjustment to be made where the sound radiated in the direction of interest is higher than that for which the sound power level is specified. In this case the sound power level is measured in a down wind direction, corresponding to the worst case propagation conditions considered here and needs no further adjustment.

7.53 In reality, the turbine noise will not spread equally in all directions, when in the plane of the rotor noise levels radiated in this direction may be significantly less, of the order of 5 dB.

A_{geo} – Geometric Spreading

7.54 The geometrical divergence accounts for spherical spreading in the free-field from a point sound source resulting in an attenuation depending on distance according to:

$$A_{geo} = 20.\log(d) + 11$$

Where d = distance from the receptor to the turbine (m)

7.55 The wind turbine may be considered as a point source beyond distances corresponding to one rotor diameter.

7.56 In order to determine the distance over which sound will travel the locations of the turbines and the receptors are required. Table 7.2 details the grid coordinates used to represent the turbine locations in the prediction of the incident noise levels at neighbouring receptors (Table 7.3).

Table 7.2: Turbine Locations

Turbine	Easting	Northing
T1	256960	241001
T2	256950	241248

Table 7.3: Receptor Locations

Turbine	Easting	Northing
Cefnblaenau	257715	241805
Esgairliving*	257075	240319
Tanrhiw*	256624	240429
Caermalwas Fawr	256459	240349

* Financially involved properties

A_{gr} – Ground Effect

7.57 Ground effect is the result of sound reflected by the ground interfering with the sound propagating directly from source to receiver. The prediction of ground effects are inherently complex and depend on the source height, receiver height, propagation height between the source and receiver and the ground conditions.

7.58 The ground conditions are described according to a variable defined as G, which varies between 0 for 'hard' ground (includes paving, water, ice, concrete & any sites with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation). Our predictions have been carried out using a source height corresponding to 10 m above a tip height, a receiver height of 4m and an assumed ground factor G = 0.5. This ground factor corresponds to a mixed ground condition between the source and receiver.

7.59 The GPG recommends the use of a ground factor of G = 0.5, provided that an appropriate margin for uncertainty is included within the source noise levels, and provided that the majority of the propagation between source and receiver does not occur over paved ground or over large bodies of water such as wide rivers or lakes. The site is mainly moorland or forestry, hence a mixed ground assumption is appropriate in this instance.

A_{atm} – Atmospheric Absorption

7.60 Sound propagation through the atmosphere is attenuated by the conversion of the sound energy into heat. This attenuation is dependent on the temperature and relative humidity of the air through which the sound is travelling and is frequency dependent with increasing attenuation towards higher frequencies. The attenuation depends on distance according to:

A_{atm} = d. a
Where d = distance from the turbine (m)
a = atmospheric absorption coefficient (dB.m^{-1})

7.61 Published values have been used for 'a' from ISO 9613 Part 1 (ISO 9613-1:1993, 1993) corresponding to a temperature of 10^{0}C and a relative humidity of 70% which give relatively low levels of atmospheric attenuation, as given in Table 7.4 below.

Table 7.4: Atmospheric Absorption Coefficient at 10oC and 70% Relative Humidity

Octave Band Centre Frequency (Hz)	63	125	250	50	1k	2k	4k	8k
Atmospheric Absorption Coefficient (dB.m-1)	0.0001	0.0004	0.0010	0.0019	0.0037	0.0097	0.0328	0.1170

7.62 This follows the guidance in the GPG which recommends the use of atmospheric conditions of 10°C and 70% to represent a reasonably low level of air absorption.

A_{bar} – Barrier Attenuation

7.63 The effect of any barrier between the noise source and the receiver position is that noise will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the noise. The barrier attenuation’s predicted by the ISO 9613 model have, however, been shown to be significantly greater than that measured in practice under down wind conditions. The results of a study of propagation of noise from wind farm sites carried out for ETSU (ETSU , 2000) concludes that an attenuation of just 2 dB(A) should be allowed where the direct line of site between the source and receiver is just interrupted and that 10 dB(A) should be allowed where a barrier lies within 5m of a receiver and provides a significant interruption to the line of site.

7.64 The GPG re-iterates the above points and suggests that topographic screening effects from the terrain should be limited to no more than 2 dB, and then only if there is no direct line of sight between the highest point on the turbine rotor and the receiver location. It also suggests that higher barrier attenuation values of up to 10 dB(A) may be appropriate if significant screening from a landform barrier is present in close proximity to the receiver.

7.65 Screening between the proposed turbine and the nearest houses has been taken into account using a digital terrain model of the proposed site. In order to not over-estimate the potential barrier attenuation, the source has been assumed at 10m above the uppermost tip height. As a consequence of this methodology, no more than 0.2 dB is assumed for barrier attenuation in the prediction of wind farm noise levels, at any assessed receptor location.

A_{misc} – Miscellaneous Other Effects

7.66 ISO 9613 includes effects of propagation through foliage, industrial plants and housing as additional attenuation effects. These have not been included here and any such effects are unlikely to significantly reduce noise levels below those predicted.

Assessment of Existing Noise Environment

7.67 Table 7.5 below details the predicted noise levels at neighbouring properties to the proposed wind turbines. The locations known as Esgairliving and Tanrhiw are financially involved with the development. Predicted levels at these locations are not predicted to exceed the noise criterion of 45 dB L_{A90}, as suggested by ETSU-R-97 for financially involved dwellings, for all wind speeds and directions, as such have not been assessed further. At the non-involved property known as Cefnblaenau the predicted levels are not expected to exceed the simplified lower fixed noise criterion suggested by ETSU-R-97 of 35 dB L_{A90}. At the non-involved property known as Caermalwas Fawr the predicted level is shown to not exceed the simplified lower fixed noise criterion suggested by ETSU-R-97 of 35 dB L_{A90} at and above 10 $m.s^{-1}$. In these circumstances, ETSU-R-97 would indicate that a background noise survey is not required at Caermalwas Fawr.

Table 7.5: Predicted Operational Noise Levels for Pencarreg: dB LA90

			Standardised Wind Speed at 10m agl. m.s-1						
Receptor	**Easting**	**Northing**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Cefnblaenau	257715	241805	25.9	31.1	32.7	33.3	33.3	33.3	33.1
Caermalwas Fawr	256459	240349	26.7	32.0	33.6	34.2	34.2	34.2	34.0

Cumulative Assessment Assumptions

7.68 One additional wind development has been considered for potential cumulative effects. This is a proposed single Enercon E53 with a 60 m hub height south west of Bryn Dafydd, submitted in 2013 and currently in planning.

Bryn Dafydd

7.69 Declared sound power levels were calculated from three measurement reports for the Enercon E53 (Müller-BBM, 27th April 2007; Windtest KWK, 24th February 2008; Müller-BBM, 14th June 2010). Octave band data used in the prediction was based on a test carried out on an existing machine (Müller-BBM, 12th July 2010). Table 7.6 shows the source sound power levels used in the prediction.

Table 7.6: Source Sound Power Level for Enercon E53 Wind Turbine, 60m hub height

dB(A) re: 10-12 W		Octave Band Centre Frequency (Hz)							
Standardised 10m agl Wind Speed: m.s-1	**LWA**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
3	95.1	76.1	83.1	85.5	87.4	90.3	89.2	83.0	73.5

dB(A) re: 10-12 W		Octave Band Centre Frequency (Hz)							
Standardised 10m agl Wind Speed: m.s-1	LWA	63	125	250	500	1k	2k	4k	8k
4	96.5	77.5	84.5	86.9	88.8	91.7	90.6	84.4	74.9
5	97.9	78.8	85.8	88.2	90.1	93.0	91.9	85.7	76.2
6	98.7	79.6	86.6	89.0	90.9	93.8	92.7	86.5	77.0
7	101.3	82.2	89.2	91.6	93.5	96.4	95.3	89.1	79.6
8	102.6	83.6	90.6	93.0	94.9	97.8	96.7	90.5	81.0
9	102.9	83.8	90.8	93.2	95.1	98.0	96.9	90.7	81.2
10	103.3	84.2	91.2	93.6	95.5	98.4	97.3	91.1	81.6
11	103.3	84.2	91.2	93.6	95.5	98.4	97.3	91.1	81.6
12	103.3	84.2	91.2	93.6	95.5	98.4	97.3	91.1	81.6

7.70 The location and hub height of this turbine is shown in Table 7.7.

Table 7.7: Bryn Dafydd Wind Turbine Location and Hub Heights

Turbine	Machine	Easting	Northing	Hub Height
1	Enercon E53	259190	238410	60

7.71 Table 7.8 below details the predicted noise levels the single turbine south west of Bryn Dafydd at properties neighbouring the proposed development.

Table 7.8: Predicted Operational Noise Levels for the Bryn Dafydd Turbine: dB LA90

			Standardised Wind Speed at 10m agl. m.s-1									
Receptor	Easting	Northing	3	4	5	6	7	8	9	10	11	12
Pantycrwys	257176	241572	3.4	4.8	6.2	7.0	9.6	10.9	11.2	11.6	11.6	11.6
Cefnblaenau	257715	241805	3.5	4.9	6.3	7.1	9.7	11.0	11.3	11.7	11.7	11.7
Caermalwas Fawr	256459	240349	4.7	6.1	7.5	8.3	10.9	12.2	12.5	12.9	12.9	12.9

7.72 Table 7.9 details the level difference between the proposed Pencarreg Development and the single E53 south west of Bryn Dafydd.

Table 7.9: Predicted level Difference between Pencarreg and the single turbine south west of Bryn Dafydd

			Standardised Wind Speed at 10 agl: m.s-1									
Receptor	Easting	Northing	3	4	5	6	7	8	9	10	11	12
Cefnblaenau	257715	241805		-21.0	-24.8	-25.6	-23.6	-22.3	-22.0	-21.4		
Caermalwas Fawr	256459	240349		-20.6	-24.5	-25.3	-23.3	-22.0	-21.7	-21.1		

7.73 It is apparent from Table 7.9 that the predicted levels from the single E53 wind turbine south west of Bryn Dafydd are more than 10 dB below the predicted levels of the proposed Pencarreg development. A cumulative assessment is therefore not required in this instance as per the guidance in ETSU-R-97.

Conclusions

7.74 An assessment of the potential noise impact associated with the proposed two wind turbine development known as Pencarreg has been performed. The guidance contained within ETSU-R-97 has been used to assess the potential noise impact of the proposed development.

7.75 Predictions of wind turbine noise have been made, based upon a sound power level for a Senvion MM100. A calculation procedure which is considered to give realistic estimates of noise imission levels has been followed.

7.76 An assessment of the potential cumulative noise impact with the proposed turbine south west of Bryn Dafydd and has been undertaken.

7.77 When considering the proposed wind turbines in isolation, predicted levels do not exceed a level of 35 dB L_{A90} at any non-involved dwelling. Therefore, the wind turbines are considered acceptable in isolation.

7.78 When considering the proposed wind turbines with the proposed turbine south west of Bryn Dafydd, no cumulative effects are predicted.

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