Technical Appendix 12.2 – Noise Prediction Methodology

Breezy Hill Energy Project - EIA Report

Brockwell Energy Limited

Prepared by: Hayes McKenzie Partnership Limited

12. Noise Prediction Methodology

12.1 Noise Prediction Methodology

12.1.1 This Technical Appendix details the prediction methodology for the operational noise predictions for the Proposed Development.

12.1.2 The standard ISO 9613-2, *Acoustics — Attenuation of sound during propagation outdoors, Part 2: General method of calculation* is used for prediction sound pressure level for downwind propagation 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:

Predicted Octave Band Noise Level = $L_w + D - A_{geo} - A_{Atm} - A_{gr} - A_{bar} - A_{misc}$

12.1.3 These factors are described in detail below together with an additional term for taking wind direction into account where required. The predicted octave band levels from each turbine are summed together to give the overall 'A' weighted predicted sound level.

L_w – Source Sound Power Level

12.1.4 The sound power level of a noise source is normally expressed in dB re: 1 pW. Noise predictions are based on sound power levels detailed in the main body of the report.

12.1.5 The octave band noise spectra used for the predictions have been taken from the technical specifications of the turbine with the results shown in the main body of the report.

D – Directivity Factor

12.1.6 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 levels is measured in a downwind direction, corresponding to the worst-case propagation conditions considered here, and needs no further adjustment.

A_{geo} - Geometrical Divergence

12.1.7 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:

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

Where d = distance from the turbine.

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

A_{atm} – Atmospheric Absorption

12.1.9 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:

$$A_{atm} = d \times \alpha$$

Where d = distance from the turbine

α = atmospheric absorption coefficient in dB/m

12.1.10 Values of 'α' from ISO 9613 Part 1 corresponding to a temperature of 10°C and a relative humidity of 70%, the values specified in the UK Institute of Acoustics, *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (IOA GPG), which give relatively low levels of atmospheric attenuation and correspondingly worst case noise predictions, are given below at Table 12.1.

Table 12.1: Frequency Dependent Atmospheric Absorption Coefficients

Octave Band Centre Frequency (Hz)	63	125	250	500	1k	2k	4k	8k
Atmospheric Absorption Coefficient (dB/m)	0.000122	0.000411	0.00104	0.00193	0.0037	0.00966	0.0328	0.117

A_{gr} – Ground Effect

12.1.11 Ground effect is the interference of sound reflected by the ground with the sound propagating directly from source to receiver. The prediction of ground effects is inherently complex and depend on the source height, receiver height, propagation height between the source and receiver, and the ground conditions. The ground conditions are described according to a variable G which varies between 0 for 'hard' ground (includes paving, water, ice, concrete and any sites with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation). The IOA GPG states that where wind turbine source noise data includes a suitable allowance for uncertainty, a ground factor of G = 0.5 and a receptor height of 4 m should be used.

A_{bar} – Barrier Attenuation

12.1.12 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 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 the study of propagation of noise from wind farm sites carried out for ETSU (DTI, 2000) concludes that an attenuation of just 2 dB(A) should be allowed where the direct line of sight between the source and receiver is just interrupted and that 10 dB(A) should be allowed where a barrier lies within 5 m of a receiver and provides a significant interruption to the line of sight.

A_{misc} – Miscellaneous Other Effects

12.1.13 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 reduce noise levels below those predicted.

12.2 Concave Ground Profile

12.2.1 Sound propagation across a concave ground profile, for example valleys or where the ground falls away significantly between the turbine and receptor, incurs an additional correction of +3 dB(A) to the overall A-weighted noise levels. This correction is implemented in order to take account of the reduced ground effects and, under some rare circumstances, the potential for multiple reflection paths caused by the concave profile.

12.2.2 A condition is recommended in the IOA GPG for indicating where this correction should be applied:

$$h_m \geq 1.5 \times \left(\frac{abs(h_s - h_r)}{2}\right)$$

Where h_m is the mean height above ground along the direct path between the source and the receptor, h_s is the absolute source height above ground level and h_r is the absolute receptor height above ground level.

12.2.3 Whilst this condition is useful at highlighting where the ground profile beneath a source to receptor path may be concave, it can produce false positives. It should therefore be used in conjunction with a visual assessment of the ground profile when determining whether a correction should be applied.

12.2.4 A computer programme is used to generate the ground profiles beneath each source – receptor path. From these plots it is possible to determine where a correction is appropriate. In this case, no concave ground profiles were identified and as such no concave corrections have been applied.

12.3 Wind Direction Effects

12.3.1 Where wind direction effects have been included in the prediction model, a supplementary term has been added to the ISO9613-2 methodology to allow for the effects of wind direction as discussed in the IOA GPG. For any given wind direction, each nearby property is classified as being either downwind, crosswind, or upwind of each of the turbines. If the house is downwind (+/-80°) of the turbine no correction is required to the predicted turbine noise level. If it is crosswind (+/-10°) of the turbine a 2 dB reduction is made to the predicted turbine noise level. If the property is upwind (+/-80°) of the turbine a reduction is made to the predicted turbine noise level due to wind shadow effects according to the methodology described in Wyle Research Report WR 88-19 as referred to in the IOA GPG. Under these conditions, this additional factor increases linearly from zero, at distances up to 5.25 x hub height, to 20 log (f) – 30, at a distance of 15.75 x hub height for flat ground. For hilly terrain this value is halved. Hayes McKenzie have modified the original Wyle methodology to include a term to scale the upwind attenuation according to the cosine of the difference between the wind direction angle and the angle corresponding to completely upwind propagation. The IOA GPG provides examples of how upwind attenuation increases with separation distance, measured in terms of turbine tip height, for flat and complex (hilly) terrain.

12.4 References

DTI (2000), ETSU W/13/00385/REP, A Critical Appraisal of Wind Farm Noise Propagation. London: Department of Trade and Industry

IOA (2013), A Good Practice Guide to the Application of ETSU-R 97 for the Assessment and Rating of Wind Turbine Noise. Milton Keynes: Institute of Acoustics.

ISO (1992), ISO 9613-1, Acoustics - Attenuation of sound during propagation outdoors, Part 1: Method of calculation of the attenuation of sound by atmospheric absorption, International Organization for Standardization.

ISO (1996), ISO 9613-2, Acoustics — Attenuation of sound during propagation outdoors, Part 2: General method of calculation.

Wyle Research Report WR 88-19, Measurement and Evaluation of Environmental Noise from Wind Energy Conversion Systems in Alameda and Riverside Counties, October 1988