atmos CONSULTING

Technical Appendix

Lairdmannoch Energy Park

Technical Appendix 9-1: Noise Prediction Methodology

Lairdmannoch Energy Park Limited

wind2

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1 Noise Prediction Methodology

Predicted Octave Band Noise Level

The ISO 9613-2 standard is used for predicting 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:

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

These factors are discussed 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

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

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

D – Directivity Factor

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.

A_{geo} – Geometrical Divergence

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

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

A_{atm} - Atmospheric Absorption

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

a = atmospheric absorption coefficient in dB/m

Values of 'a' from ISO 9613 Part 1 (ISO, 1992) 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 Turbines Noise* (IOA GPG), which give relatively low levels of atmospheric attenuation and correspondingly worst case noise predictions, as given in Table 9-1-1.

Table 9-1-1: 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

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 are 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 & 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 4m should be used.

A_{bar} - Barrier Attenuation

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 attenuations 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 (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 5m of a receiver and provides a significant interruption to the line of sight. In this case a 2 dB correction has been applied where there is no line of sight between a turbine and receptor location. The barrier attenuation corrections applied for the Proposed Development are set out at **Table 9-1-2.**

Table 9-1-2: Barrier Corrections Applied – Proposed Development

Property/Turbine	T1	T2	T3	T4	T5	T6	T7	T8
1 Gordons Cairn Glengap	0	0	0	0	0	0	0	-2
2 Gordons Cairn Glengap	0	0	0	0	0	0	0	-2
3 Gordons Cairn Glengap	0	0	0	0	0	0	0	0
4 Gordons Cairn Glengap	-2	0	0	0	0	0	0	0
5 Gordons Cairn Glengap	0	0	0	0	0	0	0	0
6 Gordons Cairn Glengap	-2	0	0	0	0	0	0	0
Cot Cottage	0	0	0	0	0	0	0	0
Edgarton Farm	0	0	0	0	0	0	0	0
Glengap	0	0	0	0	0	-2	-2	-2
Grobdale of Balmaghie	-2	0	-2	-2	0	0	0	0
Lochenbreck Byre	0	0	0	0	0	0	0	0
Lochenbreck Cottage	0	0	0	0	0	0	0	0
Miefield Farm	-2	-2	-2	0	-2	-2	0	0
The Waterhouse	-2	0	0	0	0	0	0	0

A_{misc} – Miscellaneous Other Effects

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

Concave Ground Profile

Sound propagation across a concave ground profile, for example valleys or where the ground falls away significantly between the turbine and the 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.

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

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

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.

Whilst this condition is useful at highlighting where the ground profile beneath a source – receptor path may be concave, it is inherently non-robust and 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.

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 corrections were identified.

2 References

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

International Organization for Standardization (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.