Technical Appendix 9.1

Noise Assessment Methodology

Noise Assessment Policy and Guidance

National Panning Framework 4

A.1. National Planning Framework 4 (February 2023) sets out the Scottish Government's overarching ambitions with regards to national planning. Policy 11 states that development proposals for all forms of renewable, low-carbon and zero emissions technologies will be supported, but that noise effects on communities should be assessed. Policy 23 states that development proposals that are likely to raise unacceptable noise issues will not be supported.

Planning Advice Note PAN1/2011, Planning and Noise

A.2. PAN1/2011 identifies two sources of noise from wind turbines: mechanical noise and aerodynamic noise. It states that "*good acoustical design and siting of turbines is essential to minimise the potential to generate noise*". It refers to the 'web based planning advice' on renewables technologies for onshore wind turbines.

A.3. The associated technical advice note to PAN1/2011 confirms that construction noise should be assessed using BS 5228 Noise and Vibration control on construction and open sites.

BS 5228 Noise and Vibration control on construction and open sites

A.4. BS5228 provides example criteria for the assessment of the significance of construction noise effects and a method for the prediction of noise levels from construction activities.

A.5. The relevant noise limits for construction activities continuing for more than one month are 45, 55 and 65 dB L_{Aeq}, for night-time (23:00-07:00), evening and weekends, and daytime (07:00-19:00) including Saturdays (07:00-13:00) respectively . These are the limits against which noise from construction activities are assessed. Noise from construction activities is usually controlled and minimised through a construction and environmental management plan (CEMP) which would be prepared at the time of construction. This would also cover short term construction noise impacts from activities such as track construction which may be required in the vicinity of residential receptors.

A.6. In this case as construction activities are generally distant from noise sensitive receptors, detailed assessment has been scoped out as it is anticipated that the relevant noise limits set out above will be met in practice, and therefore no significant noise construction effects are predicted.

Onshore Wind Policy Statement 2022

A.7. The Scottish Government's Onshore Wind Policy Statement (OWPS) 2022 sets out the Government's ambition to deploy 20 GW of onshore wind by 2030. OWPS section 3.7 relates to noise and refers to ETSU-R-97 and states that all applicants are required to follow the framework set out within it, supplemented by the guidance in the Institute of Acoustics (IOA) document; *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (GPG).

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

A.8. ETSU-R-97, The Assessment and Rating of Noise from Wind Farms, 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.

A.9. ETSU-R-97 recommends that, although noise limits should be set relative to existing background noise 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*.'

A.10. 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.

A.11. 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}.

A.12. Residential properties where the occupier has financial involvement with the wind farm are allowed higher ‘financially involved’ noise limits where the lower fixed limits (for both the day-time and night-time) are increased to 45 dB L_{A90}.

A.13. 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 when measured at 10 m height. This removes the need for extensive background noise measurements for smaller or more remote schemes.

A.14. It is stated that the $_{LA90,10min}$ 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.

A.15. 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.

A.16. Regarding 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

A.17. In May 2013, the IOA published A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise. The publication of the Good Practice Guide (GPG) followed a review of current practice carried out for the Department of Energy and Climate Change (DECC) and an IOA discussion document which preceded the GPG.

A.18. The GPG includes sections on Context; Background Noise 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*'.

A.19. 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.

Local Guidance

A.20. Perth and Kinross Council sets out the way in which wind energy developments should be assessed in their Renewable and Low Carbon Energy DRAFT Supplementary Guidance 2019, which builds on Policy 33 of the Local Development Plan 2 (November 2019). The supplementary guidance confirms that the operational noise impact assessment should be carried out in line with ETSU-R-97.

Construction Noise Methodology

A.21. A detailed assessment of construction noise has been deemed unnecessary due to the large separation distances between on-site construction activities and nearby noise sensitive receptors. Nevertheless, construction impacts are discussed below.

A.22. Construction activities within the Site that could give rise to the greatest levels of noise are listed below:

i. Track construction has the potential to pass closest to residential properties; and

ii. Blasting, if required, will generate the highest levels of noise at the source.

A.23. The nearest noise sensitive receptors to the proposed locations of these construction activities are:

i. For track construction (and vehicles accessing the site), Woodend Cottage at a distance of approximately 230 m from the nearest access track location;

ii. For blasting, Glenbeich Lodge, at a distance of approximately 700 m from the nearest access track borrow pit location.

A.24. Standard best practice measures to minimise noise during construction will be implemented in accordance with a detailed Construction Environmental Management Plan (CEMP), which can be secured by means of an appropriately worded planning condition.

A simplified daytime construction noise limit of 65 dB L_{Aeq} during normal working hours will be applied in accordance with the method from BS5228 discussed above.

A.25. Any potential noise issues associated with the movement of construction vehicles to and from the site would be sufficiently dealt with within the Construction Traffic Management Plan (CTMP).

A.26. Noise arising from decommissioning activities has been scoped out of further assessment on the basis that the noise levels arising are likely to be similar to those arising during the construction phase. Therefore, if construction noise impacts are acceptable then operational noise impacts will also be acceptable.

A.27. The Control of Pollution Act 1974 gives local authorities powers to control noise from construction sites. However, where construction noise remains within the relevant noise limits set out above, noise levels are considered to be acceptable, and the local authorities are unlikely to need to relay on the legislative framework set out by The Control of Pollution Act 1974.

Operational Noise Methodology

A.28. The assessment follows guidance set out in ETSU-R-97 on the assessment of noise from wind turbines which includes the following stages:

i. Predicted noise levels have been calculated/modelled using ISO 9613-2 methodology;

ii. Noise contour plots have been produced showing predicted L_{A90} at a height of 4 m above ground level assuming downwind conditions in all directions (not possible in practice but represents worst-case for all receptor locations); and

iii. Worst-case downwind predicted noise levels have been compared to the relevant ETSU-R-97 simplified noise limit.

A.29. Although not considered here, as baseline noise measurements have not been undertaken, the following ETSU-R-97 noise limits would apply if the limits were set relative to background noise levels:

i. 35-40 dB L_{A90} during the day, or 5 dB above background, whichever is the greater;

ii. 43 dB L_{A90} during the night, or 5 dB above background, whichever is the greater;

iii. 45 dB L_{A90} at financially involved properties, or 5 dB above background, whichever is the greater.

A.30. The assessment is based on the Proposed Development as described in **Chapter 2: Project Description (EIAR Volume 1)** and assumed the installation of up to 12 turbines up to 180 m tip height. For the purposes of the EIAR and this noise assessment, use of a Vestas V162 7.2 MW turbine (without serrated trailing edged) has been assumed as a worst case scenario. The candidate turbine used for the purposes of predictions are assumed to have a hub height of 99 m. It should be noted that the actual turbine selection will depend on a number of factors that will be taken into account during the procurement process, post consent and it cannot be guaranteed that this candidate turbine will be installed on the Site.

A.31. Operational noise predictions have been carried out for the candidate wind turbine under consideration for the Proposed Development in line with the methodology set out in the IOA GPG (IOA, 2013). Full details of the predictions methodology are set out below, but the main assumptions are described below:

i. Receiver height of 4 m;

ii. Ground effect coefficient G=0.5;

iii. Atmospheric attenuation corresponding to a temperature of 10°C and a relative humidity of 70%;

iv. Topographical barriers and concave ground profile corrections have been applied according to the IOA GPG (IOA, 2013); and

v. A margin of plus 2 dB has been added to manufacturer’s sound power level data to account for uncertainty.

A.32. The source noise levels for the candidate turbine assumed for the Proposed Development are set out in **Table 1** of **Confidential Technical Appendix (TA) 9.2 (EIAR Volume 5).** The octave band noise data has been taken from the manufacturers data and is also set out in **Table 1** of **Confidential TA 9.2 (EIAR Volume 5).** The sound power levels include the plus 2 dB uncertainty discussed above. It should be noted that the source noise levels used are for the turbine without serrated trailing edges (STEs), which is a non-standard configuration but provides a more conservative prediction as the overall levels are higher for a turbine without STEs. The installed turbines will likely include STEs and therefore are likely to have overall noise levels that are about 2 dB lower than those presented in **Confidential TA 9.2 (EIAR Volume 5)** and used in this assessment.

Noise Prediction Methodology

A.33. 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:

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

A.34. 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

A.35. 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.

A.36. 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

A.37. 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

A.38. 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

A.39. The wind turbine may be considered as a point source beyond distances corresponding to one rotor diameter.

A_{atm} - Atmospheric Absorption

A.40. 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

A.41. Values of 'α' from ISO 9613 Part 1[1] corresponding to a temperature of 10ºC 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 1.**

Table 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

A.42. 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 4 m should be used.

A_{bar} - Barrier Attenuation

A.43. 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

1 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, 1992

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[2] 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. In this case a 2 dB reduction to the predicted noise level has been applied where there is no line of sight between the prediction location and the turbine tip height.

A_{misc} – Miscellaneous Other Effects

A.44. 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.

Concave Ground Profile

A.45. 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.46. A condition is recommended in the IOA GPG for indicating where this correction should be applied:

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

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.

A.47. 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.48. 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.

[2] ETSU W/13/00385/REP, A Critical Appraisal of Wind Farm Noise Propagation, DTI 2000

The concave ground profile correction has been applied as calculated by the IOA GPG formula for distances up to 2 km. At further distances, it is unlikely that a concave ground profile correction would be required at this site.

Cumulative Operational Noise Modelling Assumptions

A.49. Cumulative operational noise predictions have been carried out for wind farms within 5 km of the Proposed Development.

A.50. One wind farm was identified to be included in the cumulative assessment, Glen Lednock, which is a proposed wind farm at the scoping stage. The turbine coordinates were taken from the scoping report and are outlined at **Table 2.**

Table 2 – Glen Lednock Turbine Coordinates

Turbine ID	Easting	Northing
GL1	267181	730482
GL2	267846	730633
GL3	268362	730452
GL4	268791	730128
GL5	269284	729920
GL6	269784	729705
GL7	270201	729385
GL8	270635	729092
GL9	270378	728247
GL10	270647	727786
GL11	270910	727320
GL12	269965	727480
GL13	269429	727647
GL14	269950	728586
GL15	269257	728196
GL16	268589	727863
GL17	267998	727993
GL18	268704	728486
GL19	269516	728882
GL20	269109	729210
GL21	268184	728702
GL22	268608	729419
GL23	268005	729448
GL24	267706	729876
GL25	267072	729835

A.51. The turbine type modelled for the Glen Lednock turbines was a Siemens Gamesa SG170 6.6MW turbine on a 135 m hub. The model was chosen as a worst case scenario turbine option that fitted within the turbine dimensions presented in the Glen Lednock Scoping Report. The overall sound power levels and octave band data was taken the manufacturer documentation and is shown in **Table 3**, including the plus 2 dB uncertainty described in **Paragraph A.31.v.**

Table 3 – Siemens Gamesa SG170 6.6 MW Octave Band Sound Power Level (dB L_{WA})

Standardised 10 m height wind speed	Octave Band Centre Frequency (Hz)								Broadband
	63	125	250	500	1k	2k	4k	8k	
4	81.7	88.5	90.7	91.7	94.9	94.6	90.1	78.3	100.3
5	86.6	93.4	95.6	96.6	99.8	99.5	95.0	83.2	105.1
6	88.8	96.6	99.0	98.6	102.0	102.7	98.0	86.7	107.9
7	88.7	96.1	98.7	99.2	102.8	102.4	96.8	86.0	107.9
8	88.5	95.4	98.1	99.9	103.8	101.9	95.3	85.0	108.0
9	88.5	95.4	98.1	99.9	103.8	101.9	95.3	85.0	108.0
10	88.5	95.4	98.1	99.9	103.8	101.9	95.3	85.0	108.0
11	88.5	95.4	98.1	99.9	103.8	101.9	95.3	85.0	108.0
12	88.5	95.4	98.1	99.9	103.8	101.9	95.3	85.0	108.0

A.52. The same assumptions and methodology for the operational noise predictions were used for the cumulative assessment.

Significance Criteria

Criteria for Assessing the Sensitivity of Receptors

A.53. For the purpose of the noise assessment all residential properties are treated as noise sensitive receptors with a high receptor sensitivity for noise effects. Properties which are derelict or require planning permission to return to habitable use are not classed as noise sensitive and have been scoped out of the assessment.

Criteria for Assessing the Magnitude of Impact

A.54. Construction and operational noise are assessed against fixed noise limits rather than on the basis of magnitude of impact. Accordingly, no scale of magnitude is applied to the assessment, and whether or not an effect is significant depends solely on whether the derived noise limits are predicted to be met.

Criteria for Assessing Construction Significance

A.55. The specific daytime criterion to be applied to the Proposed Development for construction noise is 65 dB $L_{Aeq,8\text{-}hour}$. This, along with evening and night limits, is detailed in **Table 4.** If the criterion is met at a specific receptor location, then the noise effect at that location is considered to be not significant.

Table 4 – Construction Noise Limits

Time Period	Limit (dB L_{Aeq})
Weekday day-time (07:00-19:00) and Saturday morning (07:00-13:00)	65
Evenings (19:00-23:00) and weekends (Saturday 13:00-19:00 and Sunday 07:00-19:00)	55
Night time (23:00-07:00)	45

Criteria for Assessing Operational Significance

A.56. The specific night and daytime noise limits to be applied to the Proposed Development for operational noise were taken from the ETSU-R-97 simplified limit of 35 dB L_{A90} at all times.

A.57. If the relevant noise limit is met at a specific receptor location, then the noise effect at that location is considered to be not significant.