Noise

Non-Technical Summary

8.1. An assessment of the effects of noise due to the Proposed Development has been undertaken.

8.2. During construction, noise may result from the use of plant and machinery to carry out construction activities. Due to the substantial separation distance between the Proposed Development and nearby residential dwellings, no significant effects are anticipated. Notwithstanding this, Best Practice mitigation measures will be adopted to manage noise emissions, including restrictions on working hours during the construction the Proposed Development.

8.3. During operation, wind turbines can generate noise from the machinery housed within the turbine and from the movement of blades through the air. Modern turbines are designed to minimise noise and planning conditions are used to ensure compliance with specified noise limits.

8.4. The assessment has been undertaken in accordance with the recommendations of ETSU R-97, the method of assessing wind turbine noise recommended by Government guidance, and following the current best practice methods described in the GPG, as endorsed by the Scottish Government. It has been shown that noise due to the Proposed Development would comply with the requirements of both ETSU R-97 and THC at the closest, and therefore all receptor locations.

8.5. A cumulative assessment has also been undertaken in conjunction with the adjacent Lochluichart, Lochluichart Extension and Corriemoillie Wind Farms. Worst-case operational noise levels are below the identified noise limits, and the impact of operational noise has therefore been shown to be acceptable.

8.6. Noise produced during decommissioning of the Proposed Development is likely to be of a similar nature to that during construction, although the duration of decommissioning will be shorter than that of construction. Any legislation, guidance or best practice relevant at the time of decommissioning would be complied with.

Introduction

8.7. This Chapter of the Environmental Impact Assessment Report (EIA Report) evaluates the noise impacts associated with the proposed Lochluichart Wind Farm Extension II (hereafter known as 'the Proposed Development'). This assessment was undertaken by Arcus Consultancy Services Limited (Arcus).

8.8. This Chapter is supported by the following Technical Appendices provided in Volume 4 of this EIA Report:

- Appendix 8.A: Cumulative Wind Turbine Noise Emission Data.

8.9. This Chapter is supported by the following figures:

- **Figure 8.1**: Cumulative Screening Plot; and
- **Figure 8.2**: Noise Contour Plot.

8.10. This Chapter includes the following elements;

- The Introduction;
- Assessment Methodology and Assessment Criteria;
- Baseline Conditions;
- Assessment of Potential Effects;
- Mitigation Measures and Residual Effects;
- Summary of Effects;
- Statement of Significance; and
- Glossary.

Assessment Methodology and Assessment Criteria

Consultation

8.11. Consultation on the scope of the EIA, the contents of the EIA Report and appropriate assessment methodologies was initially carried out through the scoping process, with further consultation carried out during the assessment process. Consultation responses relating to noise are detailed in **Table 8.1**.

Table 8.1 Summary of Consultation Response

Consultee	Consultation Response	Action
The Highland Council (THC)	It is anticipated that the simplified noise criterion will be applied, however consideration will be required on how this will operate within the cumulative context, particularly how compliance can be achieved.	Noise Modelling has shown that the ETSU-R-97[i] simplified noise criterion is achievable for the Proposed Development. Cumulative effects have been addressed through the apportionment of noise limits, to ensure compliance with the requirements of ETSU-R-97.
Transport Scotland	*"We are satisfied that there will not be any significant environmental impacts associated with increased traffic from either the construction or the operational stage of the development".*	Construction traffic on public roads is not considered significant and has therefore not been assessed. However, best practice measures for the control of noise from construction are presented in Paragraph 8.93.

Construction Noise

8.12. The following legislation, guidance and standards are of particular relevance to construction noise:

- The Control of Pollution Act 1974 (CoPA 1974)[ii];
- The Environmental Protection Act 1990 (EPA 1990)[iii]; and
- BS 5228:2009+A1:2013 Code of Practice for Noise and Vibration Control on Construction and Open Sites.

The Control of Pollution Act 1974 (CoPA 1974)

8.13. CoPA 1974 provides Local Authorities with powers to control noise and vibration from construction sites.

The Environmental Protection Act 1990 (EPA 1990)

8.14. The EPA 1990 specifies mandatory powers available to Local Authorities in respect of any noise that either constitutes or is likely to cause a statutory nuisance, which is also defined in the CoPA 1974. A duty is imposed on Local Authorities to carry out inspections to identify statutory nuisances, and to serve abatement notices against these. Procedures are also specified with regards to complaints from persons affected by a statutory nuisance.

BS 5228:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites

8.15. BS 5228:2009+A1:2014 (BS 5228) refers to the need for the protection against noise and vibration of persons living and working in the vicinity of, and those working on construction and open sites. It recommends procedures for noise and vibration control in respect of construction operations. The standard is published in two parts: Part 1- Noise and Part 2- Vibration. The discussion below relates mainly to Part 1- Noise, however, the recommendations of Part 2 in terms of vibration are broadly very similar.

8.16. The standard stresses the importance of community relations, and states that early establishment and maintenance of these relations throughout the carrying out of site operations will go some way towards allaying people's concerns. In terms of neighbourhood nuisance, the following factors are likely to affect the acceptability of construction noise:

- Site location relative to the noise sensitive premises;
- Existing ambient noise levels;
- Duration of site operations;
- Hours of work;
- The attitude of local residents to the site operator; and
- The characteristics of the noise produced.

8.17. Recommendations are made regarding the supervision, planning, preparation and execution of works, emphasising the need to consider noise at every stage of the operation.

8.18. Measures to control noise are described, including:

- Control of noise at source by, e.g:
  (a) Substitution of plant or activities by less noisy ones;
  (b) Modification of plant or equipment to reduce noise emissions;
  (c) The use of noise control enclosures;
  (d) The siting of equipment and its method of use;
  (e) Equipment maintenance; and
- Controlling the spread of noise, e.g., by increasing the distance between plant and noise-sensitive premises or by the provision of acoustic screening.

8.19. Another key revision to the standard is the inclusion of a discussion of noise control targets, and example criteria for the assessment of the significance of noise effects. These are not mandatory.

<u>Construction Noise Methodology</u>

8.20. Due to the significant separation distance between the Proposed Development and nearby noise receptors (approximately 800 m from the Proposed Development boundary to the closest receptor), rather than assessing the effects of construction noise in terms of noise level, the mitigation measures outlined in Paragraph 8.93 are to be adopted, which are considered to be Best Practice, as advocated in BS 5228.

8.21. Construction noise will be limited in duration and confined to working hours as specified by THC which can be adequately controlled through planning condition. On this basis, no further assessment of construction noise is considered necessary.

Vibration (Construction)

8.22. Occupants of residential properties near construction sites sometimes express concerns about vibration resulting from construction activities. For the Proposed Development, no scoping responses or other consultation responses have expressed concerns about vibration effects.

8.23. BS 5228-2 states…"In general, the longer the duration of activities on a site, the more likely it is that vibration from the site will prove to be an issue. In this context, good public relations and communication are important. Local residents might be willing to accept higher levels of vibration if they know that such levels will only last for a short time".

8.24. Given the large separation distance to the closest receptor, no significant vibration effects are anticipated and this has not been considered further in this Chapter.

Decommissioning

8.25. Noise produced during decommissioning of the Proposed Development is likely to be of a similar nature to that during construction, although the duration of decommissioning will be shorter than that of construction. Any legislation, guidance or best practice relevant at the time of decommissioning would be complied with.

<u>Operational Noise Guidance</u>

8.26. The following guidance and information sources have been considered in carrying out the operational noise assessment:

- The Scottish Government's planning information on onshore wind turbines[iv];
- Planning Advice Note 1/2011 (PAN1/2011): Planning and Noise[v];
- ETSU-R-97: The Assessment and Rating of Noise from Wind Farms[vi]; and
- A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise[vii].

Scottish Government planning information on onshore wind turbines

8.27. The Scottish Government's Online Renewables Planning Advice (updated 28th May 2014) states that ETSU-R-97 should be used to assess and rate noise from wind energy developments, together with the Institute of Acoustics' *Good Practice Guide*.

PAN 1/2011: Planning and Noise

8.28. PAN 1/2011 provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. It promotes the principles of good acoustic design and the appropriate location of new potentially noisy development. An associated Technical Advice Note offers advice on the assessment of noise impact and includes details of the legislation, technical standards and codes of practice appropriate to specific noise issues.

8.29. Appendix 1 of the Technical Advice Note: Assessment of Noise[viii] describes the use of ETSU-R-97 in the assessment of wind turbine noise.

ETSU-R-97

8.30. ETSU-R-97 provides a framework for the assessment and rating of noise from wind turbine installations. It is the accepted standard for wind farm developments in the UK as supported by national guidance, and the methodology has therefore been adopted for the present assessment.

8.31. Both background noise and noise from wind turbines typically vary with wind speed. According to ETSU-R-97, wind farm noise assessments should therefore consider the site-specific relationship between wind speed and background noise, along with the particular noise emission characteristics of the proposed wind turbines.

8.32. ETSU-R-97 specifies the use of the $L_{A90,10min}$ descriptor for both background and wind turbine noise. Therefore, unless otherwise specified, all references to noise levels within this Chapter relate to this descriptor. Similarly, all wind speeds referred to relate to a height of 10 m above ground level (AGL) at the location of the Proposed Development, standardised in accordance with current good practice guidance or BS:EN (IEC) 61400 11:2003 as appropriate, unless otherwise stated.

8.33. ETSU-R-97 recommends the application of external noise limits at the nearest noise-sensitive properties, to protect outside amenity and prevent sleep disturbance inside dwellings. These limits take the form of a 5 dB margin above the prevailing background noise level, except where background noise levels are lower than certain thresholds, where fixed lower limits apply. Separate limits apply for quiet daytime and night-time periods, as outlined below.

8.34. During daytime (07:00 to 23:00), the guidance specifies limits designed to protect the amenity of residents whilst enjoying the external garden areas of their properties. The limits are based on the prevailing background noise level for 'quiet daytime' periods, defined in ETSU-R-97 as:

- 18:00 – 23:00 every day;

- 13:00 – 18:00 on Saturday; and
- 07:00 – 18:00 on Sundays.

8.35. ETSU-R-97 recommends that the fixed lower noise limit for daytime should be set within the range 35 to 40 dB, $L_{A90,10min}$, with choice of value dependent on the following factors:

- The number of dwellings in the neighbourhood of the Proposed Development;
- The effect of the noise limits on the number of kWh (kilo Watt hours) generated; and
- The duration and level of exposure.

8.36. Different limits apply at night, where potential sleep disturbance is the primary concern rather than the requirement to protect outdoor amenity. Night-time is considered to be all periods between 23:00 and 07:00. A limit of 43 dB $L_{A90,10min}$ is recommended for night-time at wind speeds or locations where the prevailing wind speed-related night-time background noise level is lower than 38 dB $L_{A90,10min}$. At other times, the limit of 5 dB above the prevailing wind speed-related background noise level applies. The value of night-time fixed lower limit was selected in order to ensure that internal noise levels remained below those considered to have the potential to cause sleep disturbance, taking account of the attenuation of noise when passing from outdoors to indoors, and making allowance for the presence of open windows.

8.37. It should be noted that THC has historically wished to reduce the fixed lower limit for night-time periods from the 43 dB, $L_{A90,10min}$ provided for in ETSU-R-97, to 38 dB, $L_{A90,10min}$. This is discussed later in this chapter.

8.38. Where the occupier of the property has a financial interest in the Development, ETSU R-97 states that the fixed lower noise limit for both daytime and night-time can be increased to 45 dB(A) and that *"consideration should be given to increasing the permissible margin above background".*

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

8.39. The Good Practice Guide (GPG) was published by the Institute of Acoustics (IOA) in May 2013 and has been endorsed by the Scottish Government as current industry best practice. The guide presents best practice in the application of the ETSU-R-97 assessment methodology for wind turbine developments at the various stages of the assessment process.

8.40. In addition, the IOA published a suite of six Supplementary Guidance Notes (SGNs) in 2014, intended to support the GPG and provide additional clarification where considered necessary. The recommendations of the GPG and associated SGNs have been followed throughout this assessment.

Cumulative Noise Effects

8.41. The GPG provides advice on the assessment of cumulative noise impact, detailing a number of possible cumulative scenarios and recommended approaches. Advice is also provided with regard to the geographical scope of a cumulative noise assessment, to determine the area within which a cumulative noise assessment is necessary.

8.42. Where a new noise source is introduced to a given scenario with a noise level which is predicted to be 10 dB or more below the existing level, the increase in the total noise level is considered to be negligible. On this basis, the necessary extents of a cumulative noise assessment can be determined. Paragraph 5.1.4 of the GPG states…*"If the proposed wind farm produces noise levels within 10 dB of any existing wind farm(s) at the same receptor location, then a cumulative noise impact assessment is necessary".*

8.43. As noted in ETSU-R-97, noise from existing wind turbines should not form part of the background noise level from which noise limits for new wind energy developments are derived.

Other Issues

Low Frequency Noise and Infrasound

8.44. A study[ix], published in 2006 by acoustic consultants Hayes McKenzie on the behalf of the DTI, investigated low frequency noise from wind farms. This study concluded that there is no evidence of health effects arising from infrasound or low frequency noise generated by wind turbines, but that complaints attributed to low frequency noise were in fact, possibly due to a phenomenon known as Amplitude Modulation (AM).

8.45. In February 2013, the Environmental Protection Authority of South Australia published the results of a study into in infrasound levels near wind farms[x]. This study measured infrasound levels at urban locations, rural locations with wind turbines close by, and rural locations with no wind turbines in the vicinity. It found that infrasound levels near wind farms are comparable to levels away from wind farms in both urban and rural locations. Infrasound levels were also measured during organised shut-downs of the wind farms; the results showed that there was no noticeable difference in infrasound levels whether the turbines were active or inactive.

8.46. Bowdler et al. (2009)[xi] concludes that:

> "...there is no robust evidence that low frequency noise (including 'infrasound') or ground-borne vibration from wind farms generally has adverse effects on wind farm neighbours".

Amplitude Modulation

8.47. In its simplest form, AM, by definition, is the regular variation in noise level of a given noise source. This variation (the modulation) occurs at a specific frequency, which, in the case of wind turbines, is defined by the rotational speed of the blades, i.e. it occurs at the rate at which the blades pass a fixed point (e.g. the tower), known as Blade Passing Frequency.

8.48. A study[xii] was carried out in 2007 on behalf of the Department for Business, Enterprise and Regulatory Reform (BERR) by the University of Salford, which investigated the incidence of noise complaints associated with windfarms and whether these were associated with AM. The study defined AM as aerodynamic noise from wind turbines with a greater degree of fluctuation than normal at blade passing frequency. Its aims were to ascertain the prevalence of AM on UK windfarm sites, to try to gain a better understanding of the likely causes, and to establish whether further research into AM is required.

8.49. The study concluded that AM had occurred at only a small number (4 of 133) of windfarms in the UK, and only for between 7% and 15% of the time. It also stated that, the causes of AM are not well understood and that prediction of the effect was not currently possible.

8.50. This research was updated in 2013 by an in-depth study undertaken by Renewable UK[xiii], which has identified that many of the previously suggested causes of AM have little or no association to the occurrence of AM in practice. The generation of AM is based upon the interaction of a number of factors, the combination and contributions of which are unique to each site. With the current knowledge, it is not possible to predict whether any particular site is more or less likely to give rise to AM, and the incidence of AM occurring at any particular site remains low, as identified in the University of Salford study.

8.51. In 2016, the IOA proposed a measurement technique[xiv] to quantify the level of AM present in any particular sample of windfarm noise. This technique is supported by the Department of Business, Energy & Industrial Strategy (BEIS, formerly The Department of Energy & Climate Change) who have published guidance[xv], which follows on from the conclusions of the IOA study in order to define an appropriate assessment method for AM, including a penalty scheme and an outline planning condition. Notwithstanding this, the suggested outline planning condition is as yet unvalidated, remains in a draft form and would require site-specific legal advice on its appropriateness to a specific development.

8.52. Section 7.2.1 of the GPG therefore remains current, stating: "The evidence in relation to 'Excess' or 'Other' Amplitude Modulation (AM) is still developing. At the time of writing, current practice is not to assign a planning condition to deal with AM".

Vibration

8.53. Research undertaken by Snow in 1996[xvi] found that levels of ground-borne vibration 100 m from a wind turbine were well below criteria for 'critical working areas' given by British Standard BS6472:1992 *Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*, and were lower than limits specified for residential premises by an even greater margin.

<u>Operational Noise Assessment Methodology</u>

8.54. In summary, the assessment process comprises:

- Identification of potential receptors, i.e. residential properties and other potentially noise-sensitive locations;
- Establishment of limits for acceptable levels of wind turbine noise, based on the measured background noise levels (if applicable) and appropriate fixed lower limits as specified in ETSU-R-97;
- Prediction of the likely levels of wind turbine noise received at each receptor; and
- Comparison of the predicted levels with the noise limits.

8.55. Potential receptors in the area around the Proposed Development were initially identified from Ordnance Survey (OS) 1:25,000 Scale digital mapping and then confirmed as permanent dwellings using OS AddressBase data; a database which combines Royal Mail address data with buildings identified on large-scale OS Mapping and provides addresses, descriptions and grid references.

8.56. ETSU-R-97 does not describe a method to predict the immission levels at the nearest residential properties resulting from the operation of the wind farm. The GPG does however provide a summary of various studies on the prediction and propagation of wind turbine noise and recommends the use of the ISO-9613-2[xvii] method in calculating the levels of wind turbine noise at receptor locations (immission levels). ISO 9613-2 provides a prediction of noise levels likely to occur under worst-case conditions; those favourable to the propagation of sound, i.e. down-wind or under a moderate, ground-based temperature inversion as often occurs at night (often referred to as stable atmospheric conditions). The specific measures recommended in the GPG have been shown to provide good correlation with levels of wind turbine noise measured at operational wind farms[xviii].

8.57. Noise predictions have been made using the ISO 9613-2 noise model; the specific data and parameters recommended in the GPG are summarised below:

- The turbine sound power levels should be stated and these should include an appropriate allowance for measurement uncertainty. If the data provided contains no allowance for measurement uncertainty, or uncertainties are not provided, an additional 2 dB should be included;
- Atmospheric conditions of 10°C and 70% relative humidity should be assumed;
- The ground factor assumed should be G=0.5 (mixed ground);
- A receiver height of 4.0 m should be applied;
- Barrier attenuation should not be included, unless there is no line of sight from the receptor, in which case a 2 dB barrier effect may be included;

- An additional 3 dB should be added to noise immission levels at properties located across a valley or with heavily concave ground[1] between the property and the wind turbine(s); and
- The predicted noise levels ($L_{Aeq,t}$) should be converted to the required $L_{A90,10min}$ by subtracting 2 dB.

8.58. The GPG notes that most sites at the planning stage will not have selected a preferred turbine; therefore a candidate turbine representative of a range of turbines should be selected to provide an appropriate estimate of noise levels. Once noise levels have been predicted at the potentially affected properties, compliance with noise limits can be assessed and design advice provided to ensure noise limits are met.

8.59. The candidate turbine for the purposes of the noise assessment for the Proposed Development is the Senvion 3.6M-114, with a hub height of 76 m. The manufacturer's noise emission (sound power level) data have been obtained for this turbine, and are included Tables 8.2 and 8.3. Sound power level data provided by Senvion states that the quoted values may differ by +/- 1 dB, and so in accordance with the GPG, a 1.65 dB uncertainty value is applied across all wind speeds (i.e. 1.65 * 1 dB). Sound power level data outside the range of wind speeds specified by the manufacturer have been extrapolated from the data provided. It should also be noted that the data provided by Senvion relates to hub height wind speeds; this has therefore been adjusted to relate to standardised 10 m wind speeds, in accordance with the GPG.

8.60. The noise emission spectrum for the Senvion 3.6M-114 is not currently available; an octave band spectrum for the closest available turbine (Senvion 3.2M-114) has therefore been utilised, scaled to the maximum sound power level for the Senvion 3.6M-114 as shown in Table 8.3.

Table 8.2 Manufacturer's Noise Emission Data, Senvion 3.6M-114

	Standardised 10 m Wind Speed, ms^{-1}									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	Sound Power Level, dB, L_{WA},									
3.6M 114, 76 m hub, including 1.65 dB addition for uncertainty.	96.9	99.2	102.6	105.4	105.8	105.8	105.8	105.8	105.8	105.8

Table 8.3 Octave Band Spectra

	Octave Band Frequency (Hz)							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**

[1] Topography which is sufficiently concave to trigger the 3 dB correction is determined in accordance with the equation provided in the Good Practice Guide, page 21.

	Octave Band Frequency (Hz)							
	Sound Power Level, dB, L_{WA},							
Senvion 3.2M 114, 76 m hub, scaled to 105.8 dB(A)	86.5	94.1	100.2	100.6	98.5	95.9	92.8	87.0

Cumulative Scenario

8.61. ETSU-R-97 states that the assessment should take account of the effect of noise from all wind turbines that may affect a particular receptor. In order to facilitate this, a search was undertaken to identify any wind turbines, either operational, consented, or part of a current planning application, considered likely to result in cumulative noise impacts when assessed in conjunction with the Proposed Development.

8.62. The following developments, all operational, have the potential to contribute to cumulative noise levels at certain residential dwellings, and have therefore been considered in this assessment:

- Lochluichart Wind Farm (Siemens SWT 3.0-101 turbines, 74.5 m hub height);
- Lochluichart Extension Wind Farm (Siemens SWT 3.0-101 turbines, 74.5 m hub height);
- Corriemoillie Wind Farm (GE 2.85-103 turbines, 73.5 m hub height)

8.63. In order to identify the area (and thereby the residential dwellings) requiring assessment, a screening tool has been developed. This involves calculating a gridded noise map for the Development, and for the cumulative sites under consideration, based upon the maximum sound power levels for the turbines from each development. The difference between the grid values is then calculated to identify the area in which the difference in noise levels between the Development and the cumulative sites under consideration is less than 10 dB, in line with the requirements of the GPG discussed in Paragraph 8.42.

8.64. This 'difference map' is then overlaid with the cumulative 35 dB(A) contour. The study area for cumulative effects is then defined as that which meets both the following two conditions:

- within the cumulative 35 dB(A) contour; and
- the difference between the Proposed Development and the cumulative sites is less than 10 dB.

8.65. **Figure 8.1** presents the results of this screening figure. As can be seen, only one property (Aultguish Inn) is located within the area meeting the above conditions.

8.66. Details of the noise emission data for each cumulative development is presented in Appendix 8.A.

Selection of Fixed Lower Noise Limits

8.67. As previously discussed, the noise limits described in ETSU-R-97 are a combination of a 5 dB margin above the prevailing wind speed-dependent background noise level and fixed lower limits, applicable where background noise levels are low. These limits apply to the total level of wind turbine noise affecting a receptors (i.e. cumulative effects).

8.68. Given large number of turbines (49 in the cumulative scenario, including the Proposed Development) and small number of affected properties (one property potentially affected by the Proposed Development), a daytime fixed lower limit of 40 dB, $L_{A90,10min}$ is in accordance with ETSU-R-97 for the assessment of cumulative effects.

8.69. For the assessment of the Development in isolation, the most stringent daytime fixed lower limit of 35 dB, $L_{A90,10min}$ has been applied.

8.70. For night-time periods, ETSU-R-97 recommends a fixed lower limit of 43 dB $L_{A90,10min}$; however THC historically request a reduction of this limit to 38 dB $L_{A90,10min}$. Notwithstanding this, it is of note that the night-time fixed lower limits relating to the existing developments (i.e. Lochluichart, Lochluichart Extension and Corriemoillie) combine to give a fixed lower limit of 41 dB $L_{A90,10min}$, and therefore sets a precedent in this regard.

8.71. For the purposes of this assessment, a night-time fixed lower limit of 41 dB $L_{A90,10min}$ (i.e. no more than the existing fixed lower limit) has therefore been adopted for cumulative effects, and a lower limit of 38 dB $L_{A90,10min}$ has been adopted when considering the Development in isolation. This approach ensures compliance with ETSU-R-97, and meets THC advice.

8.72. No noise-sensitive receptors have a financial interest in the Proposed Development; the increased fixed lower limit for financial involvement stated in ETSU-R-97 has therefore not been applied in this assessment.

Baseline Conditions

8.73. As noted in ETSU-R-97, noise from existing wind turbines should not form part of the background noise level from which noise limits for new wind energy developments are derived. As discussed in Paragraph 8.68, a large number of operational wind turbines are present in the locality. It was therefore agreed during further consultation with the EHO of THC that baseline monitoring undertaken prior to the installation of the cumulative wind farms may be used for the purposes of this assessment, providing it was carried out in accordance with the methodology that went on to make up the GPG, or can be corrected to reflect GPG advice.

8.74. Baseline noise monitoring was undertaken at Aultguish Inn for the Lochluichart Wind Farm ES in 2004. Baseline noise levels at each integer wind speed have been derived from the prevailing background noise trendline equations presented in **Figures a12.12** and **a12.13** of the 2006 Lochluichart ES Addendum.

8.75. Whilst the baseline monitoring was undertaken in accordance with current best practice in all other respects, the methodology regarding the standardisation of 10 m wind speeds to account for the effect of wind shear was not in accordance with the GPG, as wind speeds were measured at a height of 20 m, rather than being at least 60% of the wind turbine's hub height. In relation to the Proposed Development, this would require wind speeds to have been measured at a height of at least 45.6 m.

8.76. Therefore, in order to account for the effect of wind shear in this assessment, it has been assumed that the baseline noise levels relate to wind speeds measured directly at 10 m, and have then been corrected to account for the effect of wind shear following the approach recommended the GPG. As some correction for wind shear is inherent in the original baseline levels, this approach results in an over correction of the baseline levels, and is therefore a conservative approach.

8.77. Section 4.5 of the GPG provides a methodology for the correction of measured 10 m wind speeds to account for wind shear effects. This methodology involves subtracting up to 3 ms^{-1} from the wind speed reference values used in the predicted noise levels. The actual value to subtract is dependent upon the hub height of the wind turbines, with lower hub heights requiring a smaller correction. A correction of 3 ms^{-1} is required for wind turbines with a hub height greater than 60 m, and is therefore applicable to this assessment.

8.78. In order to facilitate the derivation of GPG-compliant noise limits, rather than shifting the predicted wind turbine noise levels to lower wind speeds, the correction has instead been applied to the baseline noise levels, by shifting the baseline noise levels to wind speeds 3 ms^{-1} greater than they were originally measured.

8.79. Table 8.4 details the background noise levels for quiet daytime and night-time measurement periods for the only receptor requiring assessment, Aultguish Inn. In the interest of clarity, both the pre-and post-correction levels are presented, demonstrating the applied correction.

Table 8.4 Prevailing Background Noise Levels – Aultguish Inn

Receptor	Standardised 10 m Wind Speed, ms^{-1}								
	4	5	6	7	8	9	10	11	12
	Background Noise Level, dB, $L_{A90,10min}$								
Quiet Daytime									
2004 baseline	27.4	28.2	29.6	31.5	33.8	36.6	40.0	43.8	43.8
2004 baseline, including 3 ms^{-1} correction	27.0	27.0	27.0	27.4	28.2	29.6	31.5	33.8	36.6
Night-Time									

Receptor	Standardised 10 m Wind Speed, ms^{-1}								
2004 baseline	22.4	22.9	23.7	25.0	26.5	28.5	30.8	33.4	33.4
2004 baseline, including 3 ms^{-1} correction	22.2	22.2	22.2	22.4	22.9	23.7	25.0	26.5	28.5

Cumulative Noise Limits

8.80. The method of establishing these limits is described in Paragraphs 8.67 - 8.72. **Table 8.5** details the ETSU-R-97 noise limits derived from the measured background noise levels for the assessment location. It is from these limits that apportioned noise limits applicable to the Development are derived.

Table 8.5: Cumulative Noise Limits

Receptor	Standardised 10 m Wind Speed, ms^{-1}								
	4	5	6	7	8	9	10	11	12
	Cumulative Noise Limits, dB, $L_{A90,10min}$								
Daytime									
Aultguish Inn	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Night-Time									
Aultguish Inn	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0

Calculation of Apportioned Noise Limits

Cumulative Noise Levels due to Other Developments

8.81. As stated in Paragraph 8.62, three wind farms with the potential for cumulative effects in conjunction with the Development have been identified (Lochluichart Wind Farm, Lochluichart Extension Wind Farm, and Corriemoillie Wind Farm).

8.82. When assessing cumulative noise levels, consideration should be given to the noise limits applicable to each development. Where there is no reasonable prospect of a cumulative development producing noise levels up to its consented (or proposed) limits, the GPG recommends that predicted noise levels should be used along with an additional safety margin. This approach prevents the sterilisation of an area in which existing wind turbine noise levels are substantially lower than the ETSU-R-97 limits, enabling further appropriate development to be considered.

8.83. It has been found that the predicted noise levels from each cumulative development at Aultguish Inn are substantially lower than their respective noise limits. An additional safety margin of 3 dB has therefore been applied to the noise emissions of each development, on top of the required addition for uncertainty (typically 2 dB).

8.84. Details of the noise emission data for each cumulative development is presented in **Appendix 8.A**, detailing the additions to account for uncertainty and cumulative safety margins in each instance.

8.85. **Table 8.6** details the predicted 'adjusted' cumulative noise levels (excluding noise due to the Development) at Aultguish Inn. The noise assessment follows GPG advice with regard to cumulative noise effects, and as such the noise levels presented in Table 8.6 are a theoretical worst case; a number of conservative assumptions have been made, as detailed in the previous sections of this chapter.

Table 8.6: Existing Adjusted Cumulative Noise Levels

Receptor	Standardised Wind Speed at 10 m AGL, ms^{-1}								
	4	5	6	7	8	9	10	11	12
	Predicted Noise Level, dB, $L_{A90,10min}$								
Aultguish Inn	25.7	28.2	32.7	35.2	36.7	36.9	36.9	36.9	36.9

Apportioned Noise Limits

8.86. In order to determine apportioned noise limits applicable to the Development in isolation, the adjusted cumulative wind turbine noise levels in **Table 8.6** have then been logarithmically subtracted from the total ETSU-R-97 noise limits presented in **Table 8.5**. The daytime and night-time apportioned limits have then been corrected to ensure they are no greater than limits based upon the 35 dB $L_{A90,10min}$, and 38 dB $L_{A90,10min}$ fixed lower limits, as described in Paragraphs 8.68 to 8.71.

8.87. The resulting apportioned limits applicable to the Development are presented in **Table 8.7**. These limits may be presented in the planning conditions of any consent of the Development, and will ensure the Development's compliance with ETSU-R-97 when considered both individually and cumulatively.

Table 8.7: Apportioned Noise Limits

Receptor	Standardised 10 m Wind Speed, ms^{-1}								
	4	5	6	7	8	9	10	11	12
	Apportioned Noise Limit, dB, $L_{A90,10min}$								
Daytime									
Aultguish Inn	35.0	35.0	35.0	35.0	35.0	35.0	36.5	37.1	37.1
Night-Time									
Aultguish Inn	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0	38.0

Assessment of Potential Effects

8.88. **Table 8.8** details the predicted noise immission levels due to the Proposed Development, following the methodology described in Paragraph 8.57, and based on the turbine noise emission detailed in **Tables 8.2** and **8.3**.

Table 8.8: Predicted Noise Levels due to the Proposed Development

Receptor	Standardised Wind Speed at 10 m AGL, ms^{-1}								
	4	5	6	7	8	9	10	11	12
	Predicted Noise Level, dB, $L_{A90,10min}$								
Aultguish Inn	26.2	29.5	32.4	32.8	32.8	32.8	32.8	32.8	32.8

8.89. In the interest of completeness, and as requested by the EHO of THC, **Table 8.9** presents the cumulative noise immission levels, including the Proposed Development (i.e. the logarithmic sum of **Tables 8.6** and 8.8). It should be noted that the levels presented in **Table 8.9** are 'adjusted' cumulative levels, and are therefore substantially higher than the level of noise likely to be experienced in practice.

Table 8.9: Predicted Noise Levels due to the Entire Cumulative Scenario (Including the Proposed Development)

Receptor	Standardised Wind Speed at 10 m AGL, ms^{-1}								
	4	5	6	7	8	9	10	11	12
	Predicted Noise Level, dB, $L_{A90,10min}$								
Aultguish Inn	28.9	31.9	35.6	37.2	38.2	38.3	38.3	38.3	38.3

Assessment against Noise Limits

8.90. **Table 8.10** details the difference (margin) between the predicted noise levels due to the Proposed Development (Table 8.8) and the apportioned noise limits presented in **Table 8.7** for daytime and night-time periods. A negative margin indicates that the predicted noise level is below the noise limit.

Table 8.10: Margins between Predicted Noise Levels and Apportioned Noise Limits

Receptor	Standardised Wind Speed at 10 m AGL, ms^{-1}								
	4	5	6	7	8	9	10	11	12
	Margin, dB								
Daytime									
Aultguish Inn	-8.8	-5.5	-2.6	-2.2	-2.2	-2.2	-3.7	-4.3	-4.3
Night-time									
Aultguish Inn	-11.8	-8.5	-5.6	-5.2	-5.2	-5.2	-5.2	-5.2	-5.2

8.91. As can be seen in **Table 8.10**, predicted noise levels due to the Proposed Development are below the apportioned noise limits. Therefore, noise due to the Proposed Development has been shown to be compliant with the requirements of ETSU-R-97.

Mitigation Measures and Residual Effects

Construction Noise

8.92. The good practice measures detailed below are considered to be sufficient to manage the effects of noise during construction operations:

- Operations shall be limited to times agreed with THC;

- Deliveries of turbine components, plant and materials by HGV to the Proposed Development shall only take place by designated routes and within times agreed with THC;
- The site contractors shall be required to employ the best practicable means of reducing noise emissions from plant, machinery and construction activities, as advocated in BS 5228;
- Where practicable, the work programme will be phased, which would help to reduce the combined effects arising from construction operations;
- Where necessary and practicable, noise from fixed plant and equipment will be contained within suitable acoustic enclosures or behind acoustic screens;
- All sub-contractors appointed by the main contractor will be formally and legally obliged, and required through contract, to comply with all environmental noise conditions;
- Where practicable, night time working will not be carried out. Local residents shall be notified in advance of any night-time construction activities likely to generate significant noise levels, e.g., turbine erection; and
- Any plant and equipment normally required for operation at night (23:00 - 07:00), e.g., generators or dewatering pumps, shall be silenced or suitably shielded to ensure that the night-time lower threshold of 45 dB, $L_{Aeq,night}$ shall not be exceeded at the nearest noise-sensitive receptors.

8.93. Application of the above measures to manage construction noise will ensure that effects are minimised as far as is reasonably practicable and that the construction process is operated in compliance with the relevant legislation.

8.94. Following construction, no residual construction noise effects are anticipated.

Operational Noise

8.95. The levels of operational noise are predicted to be compliant with the requirements of ETSU-R-97 and THC based upon noise limits derived in accordance with ETSU-R-97 and the recommendations of the GPG.

8.96. As indicated in Paragraph 8.58, turbine selection will be subject to a competitive procurement process. At this stage, it is therefore not possible to define which turbine type would be installed. A sound power level warranty will be sought from the manufacturer of the actual turbine selected for construction. These warranted sound power levels will be used, along with any information provided on tonality, to verify that the selected model can be operated within any noise limits specified in planning conditions attached to any planning permission for the Proposed Development.

8.97. As noted in paragraph 8.87, the noise limits applicable to the Proposed Development in isolation are presented in **Table 8.7**. These limits may be presented in the planning conditions of any consent of the Proposed Development, and will ensure compliance with ETSU-R-97 when considered both individually and cumulatively.

8.98. The residual operational effects are the same as the operational effects identified in this assessment.

Summary of Effects

8.99. An assessment of potential noise effects has been carried out for the operational, construction and decommissioning stages of the Proposed Development.

8.100. The assessment has been undertaken in accordance with the recommendations of ETSU R-97, the method of assessing wind turbine noise recommended by Government guidance, and following the current best practice methods described in the GPG, as endorsed by the Scottish Government. It has been shown that noise due to the Proposed Development would comply with the requirements of both ETSU-R-97 and THC at the closest, and therefore all receptor locations.

8.101. It is therefore concluded that noise levels at all noise-sensitive properties, due to operation of the Proposed Development, would be acceptable in terms of the recommendations of both ETSU-R-97, and THC.

8.102. Construction noise will be limited in duration and confined to working hours as specified by THC and can therefore be adequately controlled through planning condition. The application of mitigation measures where applicable will also ensure that any noise from site will be adequately controlled.

8.103. Noise during decommissioning will be of a similar nature to that during construction and will be managed through best practice or other guidance or legislation relevant at the time.

Statement of Significance

8.104. Construction noise will be limited in duration and confined to working hours as agreed with THC and can therefore be adequately controlled through planning condition. The application of mitigation measures where applicable will also ensure that any noise from site will be adequately controlled such that construction noise effects are considered not significant.

8.105. Noise during decommissioning will be managed to ensure compliance with best practice, legislation and guidelines current at the time in order to ensure that effects are **not significant**.

Glossary

8.106. **AGL:** Above Ground Level

8.107. **Background Noise:** The background noise level is the underlying level of noise present at a particular location for the majority (usually 90%) of a period of time. As such it excludes any short-duration noises, such as individual passing cars (but not continuous traffic), dogs barking or passers-by. Sources of background noise typically include such things as wind noise, traffic and continuously operating machinery (e.g. air conditioning or generators).

8.108. **Decibel (dB):** The decibel is the basic unit of noise measurement. It relates to the cyclical changes in air pressure created by the sound (Sound Pressure Level) and operates on a logarithmic scale, ranging upwards from 0 dB. 0 dB is equivalent to the normal threshold of human hearing at a frequency of 1000 Hz. Each increase of 3 dB on the scale represents a doubling in the Sound Pressure Level, and is typically the minimum noticeable change in sound level under normal listening conditions. For example, while an increase in noise level from 32 dB to 35 dB represents a doubling in sound pressure level, this change would only just be noticeable to the majority of listeners.

8.109. **dB(A):** Environmental noise levels are usually discussed in terms of dB(A). This is known as the A-weighted sound pressure level, and indicates that a correction factor has been applied, which corresponds to the human ear's response to sound across the range of audible frequencies. The ear is most sensitive in the middle range of frequencies (around 1000-3000 Hertz (Hz)), and less sensitive at lower and higher frequencies. The A-weighted noise level is derived by analysing the level of a sound at a range of frequencies and applying a specific correction factor for each frequency before calculating the overall level. In practice this is carried out automatically within noise measuring equipment by the use of electronic filters, which adjust the frequency response of the instrument to mimic that of the ear.

8.110. **Frequency:** The frequency of a sound is equivalent to its pitch in musical terms. The units of frequency are Hertz (Hz), which represents the number of cycles (vibrations) per second.

8.111. **Noise Emission:** The sound power level emitted from a given source.

8.112. **Noise Immission:** The sound pressure level detected at a given location (e.g. nearest dwelling).

8.113. **$L_{A90,t}$:** This term is used to represent the A-weighted sound pressure level that is exceeded for 90% of a period of time, t. This is used as a measure of the background noise level.

8.114. **$L_{Aeq,t}$:** This term is known as the A-weighted equivalent continuous sound pressure level for a period of time, t. It is similar to an average, and represents the sound pressure level of a steady, continuous noise which has the same energy as the actual measured noise.

8.115. **Low-frequency noise:** Noise at the lower end of the range of audible frequencies (20 Hz – 20 kHz). Usually refers to noise below 250 Hz. Should not be confused with infrasound, which is sound below the lowest normally audible frequency, 20 Hz.

8.116. **Noise:** Unwanted sound. May refer to both natural (e.g. wind, birdsong etc) and artificial sounds (e.g. traffic, noise from wind turbines, etc)

8.117. **Noise sensitive receptors:** Locations that may potentially be adversely affected by the addition of a new source of noise. These can include residential properties, outdoor areas and sensitive species.

8.118. **Sound power (W):** The sound energy radiated per unit time by a sound source, measured in watts (W).

8.119. **Sound power level (L_w):** Sound power measured on the decibel scale, relative to a reference value (Wo) of 10^{-12} W.

8.120. **Sound pressure (P):** The fluctuations in atmospheric pressure relative to atmospheric pressure, measured in Pascals (Pa).

8.121. **Sound pressure level (L_p):** Sound pressure measured on the decibel scale, relative to a sound pressure of 2×10^{-5} Pa.

8.122. **Tonal element:** A characteristic of a sound where the sound pressure level in a particular frequency range is greater than in those frequency ranges immediately above higher or lower. This would be perceived as a humming or whining sound.

8.123. **Vibration:** In this context, refers to vibration carried in structures such as the ground or buildings, rather than airborne noise.

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