Environmental Impact Assessment Report

Beinneun 2 Wind Farm

Volume 1

Chapter 9: Noise

Document prepared by Metrica Environmental Consulting Ltd and Envams Ltd for Beinneun 2 Ltd

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Contents

9 NOISE

9.1 INTRODUCTION

Metrica Environmental Consulting Ltd was commissioned to prepare a Noise Impact Assessment on behalf of Beinneun 2 Ltd.

The Site is solely within the planning authority area of The Highland Council. The wind turbines and the associated infrastructure are collectively known as the Beinneun 2 Wind Farm ('the Development'). The Site and turbine layout are shown on Figure 4.1 and the Development is described in Chapter 4, Development Description. The Development would be operated for up to 40 years and then decommissioned.

The Development will comprise:

- Up to 19 wind turbines, with a maximum tip height of up to 200 m;
- Associated foundations and crane hard standings at each wind turbine location;
- Access tracks linking the turbine locations comprising of 17.5 km of new tracks;
- Battery Energy Storage System (BESS) compound containing approximately 26 no. 40-ft (or equivalent) battery containers;
- One meteorological mast;
- Network of underground cabling;
- New substation compound; and
- Two construction and storage compounds, one of which will be at the BESS/substation compounds.

This Chapter of the Environmental Impact Assessment Report (EIA Report) evaluates the potential effects of the Development on the acoustic environment of the area during the construction, operation and decommissioning.

9.1.1 Supporting Information

The following supporting Technical Appendices (TAs) have been prepared as listed below and provided in Volume 3 of this EIA Report:

- TA9.1: Sound Power Levels and Cumulative Noise Level Breakdown; and
- TA9.2: Construction Traffic Noise Calculations.

The following figures are presented in Volume 2 of this EIA Report:

- Figure 9.1: Cumulative Noise Screening Plot; and
- Figure 9.2: Noise Contour Plot.

A glossary of terms is provided in Section 9.10.

9.1.2 Competence

This Chapter was authored by Alan Moore BA(hons), Diploma in Acoustics and Noise Control, Member of the Institute of Acoustics (MIOA) and Associate of the Institute Sustainability and Environmental Professionals (AISEP). Alan is a Director and the Lead Acoustics Consultant of Metrica Environmental Consulting Ltd, with 16 years' experience in the assessment of wind farm noise, which includes a substantial number of s.36 wind farm developments in Scotland, in addition to wind farm noise assessments across the wider UK and internationally.

9.2 LEGISLATION, POLICY AND GUIDANCE

9.2.1 Construction Noise

The following guidance and information sources have been considered in the assessment of construction noise:

- The Control of Pollution Act 1974 (CoPA 1974)[1];

[1] UK Government (1974) The control of Pollution Act 1974, available at:
http://www.legislation.gov.uk/ukpga/1974/40

- The Environmental Protection Act 1990 (EPA 1990)[2]; and
- British Standard BS 5228:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites[3].

9.2.1.1 CoPA 1974

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

Section 60 of CoPA 1974 enables a Local Authority to serve a notice to persons carrying out construction work regarding the control of site noise. This notice may specify plant or machinery that is or is not to be used, the hours during which construction work may be carried out, the level of noise or vibration that may be emitted, and provide for changes in working practices.

9.2.1.2 EPA 1990

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.

9.2.1.3 BS 5228:2009+A1:2014

Guidance relevant to the effects of noise and vibration during construction and decommissioning is provided by BS 5228, which is published in two parts: Part 1 - Noise and Part 2 - Vibration. The bullet points below relate mainly to Part 1, however, the recommendations of Part 2 in terms of vibration are broadly very similar. BS 5288:

- 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;
- Recommends procedures for noise and vibration control in respect of construction operations;
- Stresses the importance of community relations, and states that early establishment and maintenance of these relations throughout site operations will go some way towards allaying people's concerns;
- Provides recommendations regarding the supervision, planning, preparation and execution of works, emphasising the need to consider noise at every stage of the operation;
- Describes methods of controlling noise at source and its spread; and
- Includes a discussion of noise control targets, and example criteria for the assessment of the significance of noise effects.

9.2.2 Operational Noise

The following guidance and information sources have been considered in the assessment of operational noise:

- The Scottish Government's 2014 web-based planning information on onshore wind turbines[4];
- Planning Advice Note 1/2011 (PAN 1/2011): Planning and Noise[5];
- ETSU-R-97: The Assessment and Rating of Noise from Wind Farms[6]; and

[2] UK Government (1990) The Environmental Protection Act 1990. Available at: http://www.legislation.gov.uk/ukpga/1990/43/contents

[3] BS 5228:2009+A1:2014 Code of Practice for noise and vibration control on construction and open sites – Part 1: Noise and Part 2: Vibration.

[4] Onshore Wind Turbines, Scottish Government. http://www.gov.scot/Resource/0045/00451413.pdf

[5] Planning Advice Note 1/2011: Planning and Noise, The Scottish Government, March 2011.

[6] ETSU-R-97 (1996) The Assessment and Rating of Noise from Wind Farms, ETSU: DTI.

- A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (the GPG)[7].

9.2.2.1 *The Scottish Government's Web-based Planning Information on Onshore Wind Turbines*

The Scottish Government's web-based information provides advice to local authorities on the planning issues associated with wind farm development. With respect to noise from wind farms, it recommends the use of ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms' and the GPG.

It goes on to refer to PAN 1/2011 as providing advice on the role of the planning system in helping to prevent and limit the adverse effects of noise, and states that the associated Technical Advice Note (TAN) Assessment of Noise[8] provides guidance which may assist in the technical evaluation of noise assessment.

9.2.2.2 *PAN 1/2011*

PAN 1/2011 promotes the principles of good acoustic design and the appropriate location of new potentially noisy development. The associated TAN 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. Appendix 1 of the TAN describes the use of ETSU R-97 in the assessment of wind turbine noise.

9.2.2.3 *ETSU-R-97*

ETSU-R-97 provides a framework for the assessment and rating of noise from wind turbine installations. It is the de facto standard for wind farm developments in the UK, and the methodology has therefore been adopted for the present assessment.

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 metres (m) AGL, standardised in accordance with the GPG.

The document 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 decibel (dB) margin above the prevailing background noise level, except where background noise levels are lower than certain thresholds, in which case fixed lower limits apply. Separate limits apply for quiet daytime and night-time periods, as outlined in Section 9.3.6 of this Chapter. The limits apply to the cumulative effects of all wind turbines that affect a particular noise-sensitive receptor (NSR).

During daytime periods, the guidance specifies limits designed to protect the amenity of residents whilst within the external amenity areas of their properties. The limits are based on the prevailing background noise level for 'quiet daytime' periods, defined in ESTU-R-97 as:

- 18:00 – 23:00 every day;
- 13:00 – 18:00 on Saturday; and
- 07:00 – 18:00 on Sundays.

ETSU-R-97 recommends that the fixed lower noise limit for daytime should be set within the range 35 to 40 dB, $L_{A90,10min}$. Different standards 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(A) is recommended at night at wind speeds or locations where the prevailing wind speed related night-time background noise level is lower than 38 dB(A). At other times, the limit of 5 dB above the prevailing wind speed related background noise level applies.

Where the occupier of the property has a financial interest in a development, ETSU-R-97 states that the fixed lower noise limit for both daytime and night-time can be increased to 45

[7] A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind turbine Noise, IOA, 2013.

[8] Technical Advice Note, Assessment of Noise, The Scottish Government, 2011

dB(A) and that *"…consideration should be given to increasing the permissible margin above background".*

9.2.2.4 The GPG

The GPG was published by the IOA in May 2013 and has been endorsed by the Scottish Government as current industry good practice. The GPG is supported by a suite of six Supplementary Guidance Notes (SGNs), published in 2014[9]. The GPG presents current good practice in the application of ETSU-R-97 assessment methodology for wind turbine developments at the various stages of the assessment process. The recommendations provided in the GPG been followed throughout this assessment.

9.2.2.5 Low-Frequency Noise and Infrasound

A study[10] on the behalf of the Department for Trade and Industry (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).

Further, in February 2013, the Environmental Protection Authority of South Australia published the results of a study into infrasound levels near wind farms[11]. 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 shutdowns of the wind farms; the results showed that there was no noticeable difference in infrasound levels whether the turbines were active or inactive.

Bowdler et al. (2009)[12] 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".

9.2.2.6 Amplitude Modulation

In 2007, a study[13] was carried out 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 wind farms and whether these were associated with AM. It defined AM as aerodynamic noise from wind turbines with a greater degree of fluctuation than normal at blade passing frequency. The study's aims were to ascertain the prevalence of AM on UK wind farm sites, to try to gain a better understanding of the likely causes, and to establish whether further research into AM was required.

The study concluded that AM has occurred at only a small number (4 of 133) of wind farms in the UK, and only for between 7% and 15% of the time when they were operational. It also states that the causes of AM are not well understood, and that prediction of the effect is not currently possible.

The 2007 study was updated in 2013 by an in-depth study undertaken by Renewable UK[14] which has identified that many of the previously suggested causes of AM have little or no association with the occurrence of AM in practice. The generation of AM is based upon the

[9] Available at: https://www.ioa.org.uk/publications/wind-turbine-noise

[10] The measurement of low frequency noise at three UK wind farms, Hayes McKenzie, The Department for Trade and Industry, URN 06/1412, 2006.

[11] Environment Protection authority (2013) Infrasound levels near wind farms and in other environments [online] Available at: http://www.epa.sa.gov.au/xstd_files/Noise/Report/infrasound.pdf

[12] Bowdler et al. (2009). Prediction and Assessment of Wind Turbine Noise: Agreement about relevant factors for noise assessment from wind energy projects. Acoustic Bulletin, Vol 34 No2 March/April 2009, Institute of Acoustics

[13] Research into aerodynamic modulation of wind turbine noise'. Report by University of Salford, The Department for Business, Enterprise and Regulatory Reform, URN 07/1235, July 2007.

[14] Renewable UK (2013). 'Wind Turbine Amplitude Modulation: Research to improve understanding as to its Cause and effects', Renewable UK, 2013.

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.

In 2016, the IOA proposed a measurement technique[15] to quantify the level of AM present any particular sample of wind farm noise. This technique is supported by the Department of Business, Energy & Industrial Strategy (BEIS), (now the Department for Energy Security and Net Zero) who have published guidance[16] 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 remains in a draft form and would require site-specific legal advice on its appropriateness to a specific development.

Section 7.2.1 of the GPG therefore remains current, stating that…*"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".*

9.2.2.7 Vibration

Research undertaken by Snow[17] found that levels of ground-borne vibration 100 m from the nearest wind turbine were significantly below criteria for 'critical working areas' given by British Standard BS 6472:1992 'Evaluation of human exposure to vibration in buildings (1 Hertz (Hz) to 80 Hz)', and were lower than limits specified for residential premises by an even greater margin.

Ground-borne vibration from wind turbines can be detected using sophisticated instruments several kilometres from a wind farm site as reported by Keele University[18]. This report clearly shows that, although detectable using highly sensitive instruments, the magnitude of the vibration is orders of magnitude below the human level of perception and does not pose any risk to human health.

9.3 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

9.3.1 Consultation

Consultation for this EIA Report topic was primarily undertaken with the Highland Council (the Council') through the Scoping process. Table 9.1 (overleaf) provides a summary of the key responses, including how / where each response has been addressed within this Chapter.

[15] Institute of Acoustics, (2016) A Method for Rating Amplitude Modulation in Wind Turbine Noise

[16] BEIS, (2016), Review of the evidence on the response to amplitude modulation from wind turbines.

[17] ETSU (1997), Low Frequency Noise and Vibrations Measurement at a Modern Wind Farm, prepared by D J Snow.

[18] Microseismic and infrasound monitoring of low frequency noise and vibrations from wind farms: recommendations on the siting of wind farms in the vicinity of Eskdalemuir, Scotland". Keele University, 2005

Table 9.1 Consultation Responses

Consultee	Type and Date	Summary of Consultation Response	Response to Consultee
The Energy Consents Unit	Scoping Opinion 01/02/2024	Confirms that ETSU-R-97, supported by the GPG is the correct methodology for the assessment of operational noise.	The stated guidance has been followed, as described in Section 9.2.2
		States that the target noise levels are 35 dB LA90 (daytime) and 38 dB L_{A90} (night-time) or up to 5dB above background noise levels at up to 12 m/s. The night-time lower limit of 43 dB L_{A90} suggested in ETSU-R-97 is not considered acceptable in many areas of the Highlands due to low background levels.	Whilst not in line with ETSU-R-97, the Council's suggested fixed lower noise limits have been considered, as discussed in Section 9.3.6
		Notes that the noise assessment should take into account the potential cumulative effect from any other existing or consented or, in some cases, proposed wind turbine developments, as describe in the GPG.	Cumulative noise effects have been assessed in line with the GPG, as described in Section 9.3.9
		Requests that the assessment includes a map showing all wind farm developments which may have a cumulative impact and all noise sensitive properties.	See Figure 9.1
		Requests a table of figures detailing: • The predicted levels from the Development at each noise sensitive location (NSL) at wind speeds up to 12m/s. • The maximum levels based on consented limits from each existing or consented wind farm development. If any reduction is made for controlling properties or another reason, this should be made clear. • The predicted levels from each existing or consented wind farm development at each NSL. • Cumulative noise levels at each NSL.	See Tables 9.9 and 9.13 See Technical Appendix A9.1 See Technical Appendix A9.1 See Technical Appendix A9.1
		When assessing the cumulative impact from more than one wind farm, consideration must be given to any increase in exposure time.	Exposure time has been considered as described in Section 9.3.6
		Agrees that construction noise effects are likely to be negligible and can be scoped out of the assessment. However, consideration will need to be given to construction traffic.	Construction traffic has been assessed as presented in Section 9.5.1. Best Practice construction methods are detailed in Section 9.6.1.
The Highland Council	Pre-App Response 04/12/2024	Reponses are a duplication of those above.	

9.3.3 Elements Scoped out of Assessment

9.3.3.1 Construction and Decommissioning Noise / Vibration

The minimum distance between any Development infrastructure and the closest noise receptor is approximately 2 km. At this distance, construction noise effects will not be significant, as agreed with the Council through the Scoping process. Rather than assessing the effects of construction noise in terms of noise level, the best practice mitigation measures outlined in Section 9.6.2 are to be adopted, as advocated in BS 5228.

Noise produced during decommissioning of the 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. On this basis, no further assessment of decommissioning noise is considered necessary.

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

9.3.3.2 Operational Noise Sources Other than Wind Turbines

Other sources of operational noise are limited to the on-site substation, which is approximately 2.3 km from the nearest NSR.

Based upon Metrica's substantial experience of such facilities, they emit relatively low levels of noise; given this, combined with the attenuation afforded by the substantial separation distance to NSRs, no significant noise effects are anticipated and substation noise has therefore not been considered further.

9.3.4 Construction Traffic Noise Assessment Methodology

Noise from construction traffic on public roads has been assessed on the basis of the change in traffic noise levels due to the addition of traffic associated with construction of the Development. Baseline traffic flows for each location have been sourced from Chapter 11: Traffic and Transport. The percentage increases in all traffic and for HGVs have then been used together with the number of vehicles, proportion of HGVs and likely speed (based on the type of road) to calculate the likely change in traffic noise level due to construction traffic, using the method described in Calculation of Road Traffic Noise (CRTN)[19].

As stated in CRTN, road traffic noise predictions are subject to a high level of uncertainty for traffic flows of less than 1,000. In such cases, noise levels will be determined following the method described in BS5228 for on-site haul roads (see Section 9.2.1.3).

9.3.5 Operational Noise Assessment Methodology

The operational noise assessment process comprises of:

- Identification of potential receptors, i.e. residential properties and other potentially noise-sensitive locations;
- If required, measurement of prevailing, wind speed dependant background noise levels at nearby properties;
- Establishment of limits for acceptable levels of wind turbine noise;
- Prediction of the likely levels of wind turbine noise received at each receptor; and
- Comparison of the predicted levels with the noise limits.

Where the distance between the Development wind turbines and nearest noise-sensitive receptors is such that predicted noise levels are no greater than the simplified criterion of 35 dB, $L_{A90,10min}$ defined in ETSU-R-97 at wind speeds measured on site of up to 10 m/s, the measurement of background noise is unnecessary, as the assessment is based on the simplified criterion.

[19] Calculation of Road Traffic Noise, Department of the Environment, 1988

9.3.6 Study Areas

The Study Area for the operational noise assessment is defined in Figure 9.1. The Study Area comprises the area where noise levels from the Development are predicted to be within both 10 dB of those from other relevant wind energy developments, and the predicted cumulative wind farm noise level (including noise due to the Development) is greater than 35 dB, $L_{A90,10min}$. The resulting Study Area is any area shaded yellow, which is located within the purple 35 dB, $L_{A90,10min}$ contour line.

9.3.7 Noise Limits

As discussed in Section 9.2.2.3, 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, subject to fixed lower limits. These limits apply to the total level of wind turbine noise affecting a receptor (i.e., cumulative effects).

Consideration of the appropriate fixed lower noise limit for daytime in the range 35 to 40 dB, $L_{A90,10min}$ has been considered in line with the three factors specified in ETSU-R 97:

- The number of dwellings in the neighbourhood of the Development:

  A low number of dwellings are located in the vicinity of the Development, particularly given the large number of turbines (82 in the existing cumulative scenario, plus 19 from the Development).

- The effect of the noise limits on the number of kilowatt hours (kWh) generated:

  Currently-consented noise limits at the dwelling most sensitive to cumulative effects (1 Achadh-luachraich) have been determined from the respective planning documents for each cumulative development. These show that the level of cumulative noise already consented is in excess of a noise limit based upon a 35 dB(A) fixed lower limit. Noise modelling has found that a fixed lower limit of 38 dB(A) is required to accommodate all of the currently consented turbines. As such, setting the daytime fixed lower limit at 38 dB(A) for the assessment of cumulative effects would be consistent with the limits applied in practice for the existing cumulative schemes.

  In the event of a daytime fixed lower limit for cumulative effects being set at less than 38 dB(A), the Development would be required to operate at 10 dB below that limit (i.e., 28 dB(A)), to ensure there was no contribution to cumulative levels. This would require the Development's turbines to be heavily mitigated, resulting in a reduction in the generating capacity of the development, and potentially rendering the Development unviable.

  For the assessment of the Development in isolation, the most stringent daytime fixed lower limit of 35 dB, $L_{A90,10min}$ has been applied, as a conservative approach; see Section 9.4.5 for details.

- The duration and level of exposure:

  The Development is located immediately adjacent to the main existing cumulative cluster comprising the existing Beinneun, Beinneun Extension and Millennium wind turbines, all of which are located to the north of the NSRs requiring assessment. Therefore, no increase in the duration of exposure associated with differing wind directions is anticipated. In addition, the prevailing wind in the UK is generally southwesterly, resulting in the closest NSRs being upwind of the turbines for the majority of the time. Noise levels at the assessed NSRs will be substantially lower than presented in this assessment under typical wind conditions.

For the above reasons, particularly bearing in mind the existing precedent in terms of consented noise limits, a daytime fixed lower limit of 38 dB(A) is consistent with the existing scenario, and appropriate for the assessment of cumulative noise effects. Notwithstanding the above, for the assessment of the Development in isolation, the most stringent daytime fixed lower limit of 35 dB, $L_{A90,10min}$ has been applied.

For night-time periods, ETSU-R-97 recommends a fixed lower limit of 43 dB $L_{A90,10min}$;. The Council historically requests a reduction of this limit to 38 dB $L_{A90,10min}$, however, the noise modelling described above has found that a night-time fixed lower limit of 39 dB(A) is required to accommodate all of the existing consented noise limits, which therefore sets a

precedent in this regard. As such, a fixed lower limit of 39 dB(A) has been applied for the night-time cumulative scenario, ensuring compliance with ETSU R-97, whilst also giving due regard to the Council's recommendations as far as possible. For the assessment of the Development in isolation, Highland Council's recommended night-time fixed lower limit of 38 dB, $L_{A90,10min}$ has been applied.

The occupants of 1 Achadh-Luachrach have a financial interest (FI) in the Development, as the owners of the land upon which the wind turbines are to be located; the increased fixed lower limit for FI stated in ETSU-R-97 has therefore been applied at this dwelling. With regard to 2 Achadh-Luachrach, the FI of the occupants is yet to be confirmed. This Chapter therefore presents two assessment scenarios (i.e. with and without the residents of 2 Achadh-Luachrach being FI).

9.3.8 Noise Modelling

In line with the GPG, noise predictions have been made using the ISO 9613-2[20] noise model, taking account of the specific data and parameters, as 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 stated, an additional 2 dB should be included;
- Atmospheric absorption should be calculated based on conditions of 10°C and 70% relative humidity;
- The ground factor assumed should be G=0.5 (mixed ground) except in urban areas or where noise propagates across large bodies of water, where G=0 (hard ground) should be assumed;
- A receiver height of 4.0 m should be assumed;
- 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 between the receptor location 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.

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[21,22].

9.3.9 Design Parameters

The GPG notes that most sites at planning stage will not have selected a preferred turbine, therefore a candidate turbine representative of a range of turbines should be selected to provide appropriate 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 compliance with the limits.

The Vestas V162 7.2 MW turbine with a hub height of 119 m has been selected as the candidate turbine for this assessment. This assessment assumes the turbines are fitted with the standard Serrated Trailing Edge (STE) blades, and operate at full power (Mode 0).

The manufacturer's noise emission data is referenced with respect to hub height wind speeds, excluding any margin for uncertainty. The sound power levels applied in this assessment have therefore been adjusted to relate to standardised 10 m wind speeds

[20] International Standard ISO 9613-2:1996 Acoustics - Attenuation of sound during propagation outdoors – Part 2: General method of calculation, International Organisation for Standardisation (ISO)

[21] Bullmore et al. (2009). Wind Farm Noise Predictions and Comparison with Measurements, Third international Meeting on Wind Turbine Noise, Aalborg, Denmark 17 – 19 June 2009.

[22] Cooper & Evans (2013). Effects of different meteorological conditions on wind turbine noise.

based upon a hub height of 119 m, plus a 2 dB allowance for uncertainly, in accordance with the GPG. The resulting sound power levels are presented in Table 9.2.

Table 9.2: Noise Emission Data – Vestas V162 7.2 MW, 119 m Hub Height

	Standardised 10 m Wind Speed, ms^{-1}								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	Sound Power Level, dB L_{WA}								
Sound Power Level, inc. 2 dB allowance for uncertainty	96.9	101.4	105.6	106.6	106.8	107.1	107.3	107.3	107.3

The octave-band frequency spectrum equivalent to the maximum sound power level (including 2 dB allowance for uncertainty) is detailed in Table 9.3.

Table 9.3: Octave Band Noise Data – Vestas V162 7.2 MW, 119 m Hub Height

	Octave Band Centre Frequency, Hz							
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
	Sound Power Level, dB L_{WA}							
Sound Power Level, scaled to 107.3 dB, L_{WA}	88.1	95.8	100.6	102.5	101.3	97.2	90.1	80.0

9.3.10 Cumulative Noise Assessment

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

The following cumulative developments were identified:

- Beinneun – operational;
- Beinneun Extension – operational;
- Bunnloin – consented;
- Millennium (including extension) – operational
- Millennium East – in planning; and
- Tomchrasky – in planning.

Details of the noise emission data for each cumulative development, is presented in Technical Appendix A9.1 in the interest of completeness.

9.3.10.1 Apportioned Noise Limits

Cumulative noise effects have been addressed through the derivation of apportioned noise limits. Apportioned noise limits are created by logarithmically subtracting the cumulative noise scenario (i.e. excluding noise due to the Development), from the cumulative noise limits. The result is the remaining noise budget available to the Development. Should no noise budget be available at a given NSR, limits at that NSR for noise due to the Development are set 10 dB below the cumulative noise limit, ensuring that any contribution to operational noise due to the Development is negligible.

9.3.11 Significance of Effect

9.3.11.1 Construction Traffic Noise

The magnitude of effects, in terms of the predicted change in traffic noise levels on public roads, expressed as $L_{A10,18hour}$ in accordance with CRTN, and based on criteria defined in DMRB[23] are defined as follows:

- Negligible: change of less than 1 dB;
- Minor: change of 1 to 3 dB;
- Moderate: change of 3 to 5 dB; and
- Major: change of 5 dB or more

Effects of Moderate or Major magnitude are considered to be significant in terms of the EIA Regulations. Effects of Negligible or Minor magnitude are considered to be not significant in terms of the EIA Regulations.

As stated in Section 9.3.3, CRTN notes that road traffic noise predictions are subject to a high level of uncertainty for traffic flows of less than 1,000. In such cases, noise levels will be determined following the method described in BS5228 for on-site haul roads. Using this method, noise generated by construction traffic is potentially significant if the L_{Aeq} level of construction traffic noise exceeds 65 dB(A) during daytime periods.

9.3.11.2 Operational Noise

The acceptable limits for wind turbine operational noise are clearly defined in ETSU-R-97, the methodology for assessment of wind turbine noise recommended by Government guidance. Therefore, this assessment determines whether the calculated immission levels at nearby NSRs lie below the noise limits derived in accordance with ETSU-R-97. Where the noise immission levels at NSRs are shown to be below derived noise limits, the impact is considered to be not significant.

9.3.12 Assessment Limitations

No significant assessment limitations have been identified.

9.4 BASELINE CONDITIONS

9.4.1 Identification of Receptors

Potential noise-sensitive receptors have been identified using Ordnance Survey MasterMap AddressBase data, along Ordinance Survey 1:25,000 scale digital mapping and online aerial imagery. As stated in section 9.3.5, the Study Area comprises the area where noise levels from the Development are predicted to be less than 10 dB of those from other relevant wind energy developments, and the predicted cumulative wind farm noise level is greater than 35 dB, $L_{A90,10min}$. The NSRs shown in Table 9.4 have been identified for assessment, being representative of all those located within the Study Area.

As discussed in Section 9.3.6, The occupants of 1 Achadh-Luachrach have a financial interest (FI) in the Development, as the owners of the land upon which the wind turbines are to be located. With regard to 2 Achadh-Luachrach, the FI of the occupants is yet to be confirmed. This Chapter therefore presents two assessment scenarios (i.e. with and without the residents of 2 Achadh-Luachrach being FI).

[23] Design Manual for Roads and Bridges, Highways Agency / Transport Scotland, Volume II Environmental Assessment, Section 3 Environmental Assessment Techniques, Part 7 HD 213/11 , Noise and Vibration – Revision 1, November 2011, Table 3.1 – Classification of Magnitude of Noise Impacts in the Short Term

Table 9.4: Assessed NSRs

Name	Financial Involvement	Easting	Northing
1 Achadh-luachraich	Yes	225148	803263
2 Achadh-luachraich (FI)	Yes	225174	803241
2 Achadh-luachraich (non-FI)	No		
Ardochy House	No	221026	802341
Caledonian Cabin	No	224241	802787
Daingean	No	223995	802684

Providing compliance with noise limits can be demonstrated at these NSRs, limits will therefore also be achieved at all other NSRs.

9.4.2 Background Noise Levels

Background noise levels presented in the Beinneun Extension Wind Farm ES have been utilised for the purposes of this assessment, as these were undertaken prior to any other wind turbines becoming operational in the local area. These background noise measurements were undertaken in full accordance with current best practice (i.e. the GPG), and therefore remain suitable for use. It should be noted that the background noise levels were originally standardised to a height of 10 m, based upon a hub height of 79.5 m, in line with the candidate turbine type for Beinneun Extension Wind Farm. Whilst the candidate turbine type for the Development is greater, these background noise levels are considered to remain suitable for use for the following reasons:

- The effect on noise limits would be negligible (i.e. no change for the majority of wind speeds as the fixed lower limit applies, and change of less than approximately 0.5 dB at all other speeds);
- The large majority of turbines in the cumulative scenario are of similar or lower hub height to that used for the Beinneun Extension background noise data analysis, meaning that the background noise levels better reflect the cumulative scenario without any correction being applied; and
- The background noise levels presented in the Beinneun Extension EIA Report are lower than those presented in EIA Report for the consented Tomchrasky Wind Farm, at all locations and wind speeds, despite the background noise levels in the Tomchrasky Wind Farm assessment being based upon a greater (110 m) hub height.

Table 9.5 details the daytime and night-time background noise levels used in this assessment.

Table 9.5: Background Noise Levels

	Standardised 10 m Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	Prevailing Background Noise Level, dB, $L_{A90,10min}$								
Daytime									
1 Achadh-luachraich	27.3	28.3	29.7	31.5	33.7	36.2	39.0	42.1	45.4
Ardochy House	27.4	29.1	31.1	33.4	35.8	38.2	40.6	42.7	44.4
Night-time									
1 Achadh-luachraich	26.0	26.8	27.9	29.2	30.7	32.4	34.4	36.6	36.6
Ardochy House	24.4	25.8	27.5	29.4	31.5	33.9	36.5	39.3	39.3

9.4.4 Noise Limits

The method for establishing the noise limits is described in Section 9.3.6.

For each assessed NSR within the Study Area (identified in Table 9.4), proxy background noise levels have been selected based on the distance between the monitoring location and the property in question, and the likely similarity of the local noise environment.

Table 9.6 details the ETSU-R-97 noise limits derived from the measured background noise levels for each NSR detailed in Table 9.4. It is from these limits that apportioned noise limits applicable to the Development are derived.

Table 9.6: ETSU-R-97 Cumulative Noise Limits

	Source of Background Noise Data	**Standardised 10 m Wind Speed, m/s**								
		4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
		Cumulative Noise Limit, dB, $L_{A90,10min}$								
Daytime										
1 Achadh-luachraich	1 Achadh-luachraich	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.1	50.4
2 Achadh-luachraich (FI)	1 Achadh-luachraich	45.0	45.0	45.0	45.0	45.0	45.0	45.0	47.1	50.4
2 Achadh-luachraich (non-FI)	1 Achadh-luachraich	38.0	38.0	38.0	38.0	38.7	41.2	44.0	47.1	50.4
Ardochy House	Ardochy House	38.0	38.0	38.0	38.4	40.8	43.2	45.6	47.7	49.4
Caledonian Cabin	1 Achadh-luachraich	38.0	38.0	38.0	38.0	38.7	41.2	44.0	47.1	50.4
Daingean	1 Achadh-luachraich	38.0	38.0	38.0	38.0	38.7	41.2	44.0	47.1	50.4
Night-time										
1 Achadh-luachraich	1 Achadh-luachraich	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
2 Achadh-luachraich (FI)	1 Achadh-luachraich	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0
2 Achadh-luachraich (non-FI)	1 Achadh-luachraich	39.0	39.0	39.0	39.0	39.0	39.0	39.4	41.6	41.6
Ardochy House	Ardochy House	39.0	39.0	39.0	39.0	39.0	39.0	41.5	44.3	44.3
Caledonian Cabin	1 Achadh-luachraich	39.0	39.0	39.0	39.0	39.0	39.0	39.4	41.6	41.6
Daingean	1 Achadh-luachraich	39.0	39.0	39.0	39.0	39.0	39.0	39.4	41.6	41.6

9.4.5 Wind Turbine Noise Levels from Other Developments

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.

An additional safety margin of 2 dB has therefore been applied to the noise emissions of each respective development, on top of the required addition for uncertainty (typically a further 2 dB). Where this additional safety margin results in predicted noise levels greater

than the applicable noise limit at a given wind speed, noise emission levels are set such that the limit is just met at that wind speed.

With specific regard to Millennium East Wind Farm, it is understood that at the time of writing the development planning application is in the process of being validated before being released in the public domain. As such, as it is not possible to determine the development's headroom in relation to its site-specific noise limits, a 2 dB safety margin has also been applied to the noise emissions from Millennium East Wind Farm as a worst case approach.

Details of the noise emission data for each cumulative development are presented in Technical Appendix A9.1, showing the required adjustments in each instance. As requested by the Council, Technical Appendix A9.1 also provides a breakdown of noise levels from each cumulative development, at each assessed receptor.

Table 9.7 presents the resulting noise levels for the existing scenario (i.e. excluding noise due to the Development). It should be borne in mind that the noise assessment follows GPG advice with regard to cumulative noise effects, and as such the noise levels presented in Table 9.7 are a theoretical worst case; a number of conservative assumptions have been made as detailed in the previous sections of this Chapter, including the assumption that each receptor is directly downwind of all turbines simultaneously, which cannot occur in practice.

Table 9.7: Existing Cumulative Noise Scenario (Excluding the Development)

	Standardised 10 m Wind Speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	Cumulative Noise Level, dB, $L_{A90,10min}$								
1 Achadh-luachraich	28.7	32.3	35.6	36.8	37.1	36.8	36.8	36.8	36.8
2 Achadh-luachraich (FI)	28.8	32.4	35.7	36.9	37.2	36.9	36.9	36.9	36.9
2 Achadh-luachraich (non-FI)	28.8	32.4	35.7	36.9	37.2	36.9	36.9	36.9	36.9
Ardochy House	24.9	28.6	32.0	33.3	33.5	33.2	33.2	33.2	33.2
Caledonian Cabin	26.9	30.5	33.9	35.1	35.4	35.1	35.1	35.1	35.1
Daingean	26.4	30.0	33.3	34.6	34.8	34.5	34.5	34.5	34.5

9.4.6 Calculation of Apportioned Noise Limits

As described in Section 9.3.9.1, the cumulative wind turbine noise levels (Table 9.7) have then been logarithmically subtracted from the total cumulative ETSU-R-97 noise limits (Table 9.6) to determine apportioned noise limits applicable to the Development in isolation. Where no noise budget remains at a given property / wind speed, limits for noise due to the Development are set 10 dB below the respective cumulative noise limit, ensuring that any contribution to cumulative noise levels is negligible.

For non-financially involved properties, the apportioned limits have then been corrected to ensure they do not exceed the limits for the Development in isolation specified in Section 9.3.6.of:

- 35 dB $L_{A90,10min}$, or 5 dB above background (daytime); and
- 38 dB $L_{A90,10min}$, or 5 dB above background (night-time).

The resulting apportioned limits applicable to the Development are presented in Table 9.8. These limits may be presented in the planning conditions of the deemed planning permission for the Development, and will ensure the Development's compliance with ETSU-R-97 when considered both individually and cumulatively.

Table 9.8: Noise Limits Applicable to the Development in Isolation

	Standardised 10 m Wind Speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	Noise Limit, dB, $L_{A90,10min}$								
Daytime									
1 Achadh-luachraich	44.9	44.8	44.5	44.3	44.2	44.3	44.3	46.7	50.2
2 Achadh-luachraich (FI)	44.9	44.8	44.5	44.3	44.2	44.3	44.3	46.7	50.2
2 Achadh-luachraich (Non-FI)	35.0	35.0	34.1	31.5	33.4	39.2	43.1	46.7	50.2
Ardochy House	35.0	35.0	36.1	36.8	39.9	42.7	45.3	47.5	49.3
Caledonian Cabin	35.0	35.0	35.0	34.9	36.0	40.0	43.4	46.8	50.3
Daingean	35.0	35.0	35.0	35.3	36.4	40.2	43.5	46.9	50.3
Night-time									
1 Achadh-luachraich	44.9	44.8	44.5	44.3	44.2	44.3	44.3	44.3	44.3
2 Achadh-luachraich (FI)	44.9	44.8	44.5	44.3	44.2	44.3	44.3	44.3	44.3
1 Achadh-luachraich (Non-FI)	38.0	37.9	36.3	34.8	34.3	34.8	35.8	39.8	39.8
Ardochy House	38.0	38.0	38.0	37.6	37.6	37.7	40.8	43.9	43.9
Caledonian Cabin	38.0	38.0	37.4	36.7	36.5	36.7	37.4	40.5	40.5
Daingean	38.0	38.0	37.6	37.0	36.9	37.1	37.7	40.7	40.7

9.5 ASSESSMENT OF POTENTIAL EFFECTS

9.5.1 Construction Traffic Noise

Baseline and construction traffic data have been taken from Chapter 11: Traffic and Transport, for the construction phase month with the highest number of traffic movements (month 6). Details of the calculation of road traffic noise levels are contained in Technical Appendix A9.2.

Table 9.9 provides a summary of the results for the estimated worst case increase in traffic flows for each location.

Table 9.9: Predicted Construction Traffic Noise Effects

Location	Change in Traffic Noise Level, dB
A82(T) Spean Bridge	0.9
A82(T) Drumnadrochit	1.0
A87(T) Bunloyne	2.6
A87(T) Auchtertyre	0.2
A87(T) Skye Bridge	0.2

It can be seen from Table 9.9 the predicted change in the level of road traffic noise during construction of the Development is less than 3 dB in all cases, with no more than a minor magnitude of impact.

With specific regard to the A887, the baseline daily traffic flow was found to be less than 1,000 vehicles in total. Therefore, and as described in Section 9.3.10.1, noise levels for the A887 have been calculated in accordance with BS5228. As shown in Appendix A9.2, a construction traffic noise level of 50.4 dB was calculated for dwellings along the A887; this is below the daytime threshold of 65 dB, L_{Aeq}, and is therefore acceptable.

It is therefore concluded that construction traffic noise effects would be **not significant** in terms of the EIA Regulations.

9.5.2 Operational Noise

Table 9.10 details the predicted noise immission levels due to the operation of the Development, following the methodology described in Section 9.3.7, and using the noise emission data presented in Section 9.3.8. These levels are also presented graphically in Figure 13.2.

Table 9.10: Predicted Noise Levels due to the Development in Isolation

	Standardised 10 m Wind Speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	Predicted Noise Level, dB, $L_{A90,10min}$								
1 Achadh-luachraich	24.1	28.6	32.8	33.8	34.0	34.3	34.5	34.5	34.5
2 Achadh-luachraich	23.9	28.4	32.6	33.6	33.8	34.1	34.3	34.3	34.3
Ardochy House	20.1	24.6	28.8	29.8	30.0	30.3	30.5	30.5	30.5
Caledonian Cabin	22.0	26.5	30.7	31.7	31.9	32.2	32.4	32.4	32.4
Daingean	22.0	26.5	30.7	31.7	31.9	32.2	32.4	32.4	32.4

Table 9.11 overleaf details the difference (margin) between predicted noise immission levels (Table 9.10) and the apportioned noise limits (Table 9.8) for the assessed receptors. A negative margin indicates that the predicted noise level is below the derived noise limit. Limit exceedances are highlighted in bold.

Table 9.11: Margin between Predicted Turbine Noise and Noise Limits

	Standardised 10 m Wind Speed, m/s								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	Margin, dB								
Daytime									
1 Achadh-luachraich	-20.8	-16.2	-11.7	-10.5	-10.2	-10.0	-9.8	-12.2	-15.7
2 Achadh-luachraich (FI)	-21.0	-16.4	-11.9	-10.7	-10.4	-10.2	-10.0	-12.4	-15.9
2 Achadh-luachraich (Non-FI)	-11.1	-6.6	-1.5	**2.1**	**0.4**	-5.1	-8.8	-12.4	-15.9
Ardochy House	-15.0	-10.5	-7.4	-7.1	-10.0	-12.5	-14.9	-17.1	-18.9
Caledonian Cabin	-13.0	-8.5	-4.3	-3.2	-4.1	-7.8	-11.0	-14.4	-17.9
Daingean	-13.0	-8.5	-4.3	-3.6	-4.5	-8.0	-11.1	-14.5	-17.9
Night-time									
1 Achadh-luachraich	-20.8	-16.2	-11.7	-10.5	-10.2	-10.0	-9.8	-9.8	-9.8
2 Achadh-luachraich (FI)	-21.0	-16.4	-11.9	-10.7	-10.4	-10.2	-10.0	-10.0	-10.0
1 Achadh-luachraich (Non-FI)	-14.7	-9.5	-3.7	-1.2	-0.5	-0.7	-1.5	-5.5	-5.5
Ardochy House	-18.8	-14.1	-9.3	-7.9	-7.7	-7.5	-10.4	-13.5	-13.5
Caledonian Cabin	-16.7	-11.8	-6.7	-5.0	-4.6	-4.5	-5.0	-8.1	-8.1
Daingean	-16.8	-11.9	-6.9	-5.3	-5.0	-4.9	-5.3	-8.3	-8.3

As Table 9.11 shows, worst-case noise levels due to the Development are below the respective noise limits in all cases, with the exception of 2 Achadh-luachraich (non-FI).

In the event that the occupants of 2 Achadh-luachraich are not FI, minor exceedances of the apportioned noise limit are predicted at wind speeds of 7 and 8 m/s during daytime periods only.

In such a scenario, mitigation would therefore be required to ensure the Development is able to operate in compliance with the requirements of ETSU-R-97. An example mitigation strategy is presented in Section 9.7.2

9.6 MITIGATION AND RESIDUAL EFFECTS

9.6.1 Construction Noise

The good practice measures detailed below will be implemented to manage the effects of noise during construction operations, and will be required of all contractors:

- Operations shall be limited to times agreed with the Council;
- Deliveries of turbine components, plant and materials by HGV to site shall only take place by designated routes and within times agreed with the Council;
- 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, non-tonal and / or directional reversing alarms should be used;
- Where practicable, the work programme will be phased, which would help to reduce the combined effects arising from several noisy 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 NSRs.

Noise produced during decommissioning of the 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, such that residual effects would be **not significant** as per the EIA Regulations.

9.6.2 Operational Noise

As discussed in Section 9.5.2, in the event that the occupants of 2 Achadh-luachraich are not FI in the Development, a suitable noise mitigation scheme would be required for daytime periods (07:00 - 23:00).

The control systems of modern wind turbines are capable of controlling the noise emissions through the management of factors such as rotational speed and blade pitch at certain wind speeds, wind directions and / or times of day. It will therefore be possible to manage the noise emissions of the Development to ensure compliance with appropriate noise limits.

The candidate turbine features a range of operational modes which provide noise reductions at various wind speeds. Modes SO3 and SO6 have been utilised for the purposes of this assessment, the sound power levels for which are provided in the Vestas V162 standard noise emission data document. Table 9.12 details the respective noise emissions for Modes SO3 and SO6.

Table 9.12: Noise Emission Data – Vestas V162 7.2 MW Reduced Noise Modes

	Standardised 10 m Wind Speed, ms^{-1}								
	4	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
	Sound Power Level, dB L_{WA}								
Mode SO3 Sound Power Level, inc. 2 dB allowance for uncertainty	96.9	101.1	102.9	103.0	103.0	103.0	103.0	103.0	103.0
Mode SO6 Sound Power Level, inc. 2 dB allowance for uncertainty	96.9	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Using the reduced-noise modes detailed in Table 9.12, an example mitigation strategy has been developed, which will result in noise levels no greater than the apportioned noise limits for the Development; this is presented in Table 9.13. The numbers shown in Table 9.13 reflect the required operating modes. Where Table 9.13 shows '-', the turbine can be operated in Mode 0 (i.e. full power). Mode 0 can be applied at all wind speeds and directions other than those specified, subject to any limitations in the turbines' control systems.

Table 9.13: Example Mitigation Strategy (Daytime only), 7 – 8 m/s

Turbine Number	Wind Direction, Degrees											
	0	30	60	90	120	150	180	200	240	270	300	330
	Applicable Operational Mode (Wind Speeds of 7-8 m/s)											
1	-	-	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-
8	SO3	-	-	-	-	-	-	-	-	-	SO6	SO3
9	SO6	SO3	-	-	-	-	-	-	-	SO3	SO6	SO6
10	SO6	SO3	-	-	-	-	-	-	-	SO3	SO6	SO6
11	-	-	-	-	-	-	-	-	-	-	-	-
12	SO6	SO3	SO3	-	-	-	-	-	-	SO3	SO6	SO6
13	-	-	-	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-	-	-
15	SO6	SO3	-	-	-	-	-	-	-	-	-	SO3
16	-	-	-	-	-	-	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-	-	-	-
19	-	SO3	-	-	-	-	-	-	-	-	-	-

Table 9.14 shows the predicted noise levels following mitigation, for the worst-case wind direction at the receptor where exceedances of the noise limit were identified (2 Achadh-luachraich (non-FI only)).

Table 9.14: Predicted Mitigated Noise Levels

	Standardised 10 m Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	Predicted Mitigated Noise Level, dB, $L_{A90,10min}$								
2 Achadh-luachraich (non-FI)	24.1	27.9	31.0	31.5	31.6	32.2	32.4	32.4	32.9

Table 9.15 details the difference (margin) between predicted noise immission levels following mitigation, (Table 9.13) and the apportioned noise limits (Table 9.8) for the receptor where an exceedance was identified. As no mitigation is required during night-time periods, Table 9.15 shows the margin for the daytime period only.

Table 9.15: Margin between Mitigated Turbine Noise and Noise Limits

	Standardised 10 m Wind Speed, m/s								
	4	5	6	7	8	9	10	11	12
	Margin dB								
2 Achadh-luachraich (non-FI)	-10.9	-7.1	-3.3	0.0	-1.7	-7.0	-10.7	-14.3	-17.3

As can be seen, In the event that the occupants of 2 Achadh-luachraich are not FI with the Development, the apportioned noise limits would be met subject to appropriate mitigation during daytime periods.

Alternatively, in the event that that the occupants of 2 Achadh-luachraich FI with the Development, noise limits would be met with no mitigation required.

In either case, the Development is able to operate in compliance with ETSU-R-97, both in isolation, and cumulatively.

Once the precise turbine type to be constructed has been selected, the mitigation scheme would be refined in consultation with the respective wind turbine manufacturer.

It is recommended that planning conditions are applied to any permission for the Development that limit noise immission levels to those levels specified in Table 9.8.

Residual effects with appropriate mitigation applied would be **not significant** as per the EIA Regulations.

9.7 CUMULATIVE EFFECT ASSESSMENT

Cumulative noise effects are included in the assessment of operational noise presented above.

9.8 SUMMARY OF EFFECTS

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

Construction noise has been assessed construction noise effects, including noise from construction traffic on public roads would be not significant due to the level and temporary nature of the work.

Operational noise has been assessed in accordance with ETSU-R-97 and in line with current best practice. In the event that the occupants of 2 Achadh-luachraich are not FI with the Development, the apportioned noise limits would be met subject to appropriate mitigation during daytime periods. Alternatively, in the event that that the occupants of 2 Achadh-luachraich are FI with the Development, noise limits would be met at all NSRs, without the requirement for any mitigation.

In either case, the Development is able to operate in compliance with ETSU-R-97, both in isolation, and cumulatively.

The cumulative effects of the Development in conjunction with any nearby wind energy developments either operational, consented or the subject of a current planning application were taken into consideration in the above assessment, by reducing the full ETSU-R-97 noise limits to account for the effects of other wind turbines, in accordance with ETSU-R-97 and the Good Practice Guide.

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

9.9 STATEMENT OF SIGNIFICANCE

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

The effect of operational noise has been assessed using the methodology described in ETSU-R-97 and the GPG, and found to be acceptable. The effect of operational noise is therefore **not significant**.

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.**

9.10 GLOSSARY

AGL: Above Ground Level

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).

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.

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.

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.

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

$L_{A90,t}$: 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.

$L_{Aeq,t}$: 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.

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.

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

Noise-sensitive receptors: Locations that may potentially be adversely affected by the addition of a new source of noise (typically residential dwellings).

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

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

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

Sound pressure level (L_p): Sound pressure measured on the decibel scale, relative to a sound pressure of 2 x 10-5 Pa.

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.

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