

Chapter 11: Noise and Vibration

Chapter 11

Noise and Vibration

Introduction

11.1 This chapter considers the potential construction and operational noise and vibration effects of the Proposed Development on nearby residential receptors.

11.2 The assessment was undertaken by Hayes McKenzie Partnership Ltd and according to the recommendations of ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms*, supplemented by the best practice guidance on its use published by the Institute of Acoustics (IOA), *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (GPG) and its associated Supplementary Guidance documents. These documents are both referred to within planning guidance provided by the Scottish Government. Construction noise has been discussed with reference to BS 5228 *Code of Practice for Noise and Vibration Control on Construction and Open Sites*.

Scope of the Assessment

Effects Assessed in Full

11.3 The following effects were identified at the Scoping stage for consideration in this assessment:

- Direct and cumulative effects during construction resulting in noise at sensitive dwellings; and
- Direct and cumulative effects during operation resulting in noise at the nearest dwellings neighbouring the Site.

Effects Scoped Out

11.4 On the basis of preliminary desk-based work undertaken, the professional judgement of the EIA team, experience from other relevant projects and policy guidance or standards, and feedback received from consultees, the following topic areas have been 'scoped out' of detailed assessment, as proposed in the EIA Scoping Report.

Bothies (Non-dwelling Buildings)

11.5 Operational and construction noise has not been assessed at the three bothies located to the east of the Site on the basis that two of these bothies are locked and the other is not a "building used for long-term residential purposes", as detailed in ETSU-R-97.

Construction and Decommissioning Effects

11.6 The construction of the Proposed Development will occur at distances that will not result in noise levels that will breach typical construction noise limits prescribed within relevant guidance such as BS 5228, *Code of Practice for Noise and Vibration Control on Construction & Open Sites*. This, combined with the temporary nature of the works, means that a detailed assessment of these construction noise effects is not considered necessary. However, some discussion has been provided in terms of relevant controls that may be put in place to limit noise associated with the provision and use of access routes and tracks.

11.7 The potential cumulative effect of noise associated with construction traffic related to multiple wind farm developments has not been considered in any detail within this assessment. It is unusual for construction noise assessments to consider this type of cumulative effect since the temporary nature of construction and uncertainty over build dates means it is very difficult (particularly at the planning stage) to predict whether construction noise arising from multiple developments would occur at the same time. However, it is acknowledged that there are a number of wind farm proposals at a similar stage of planning in the area including Bhlaraidh Wind Farm Extension (consented), Chraithaich (design/Scoping stage) and Fiodhag (design/Scoping stage) which does raise the possibility of multiple developments being constructed at the same time. It is expected that any respective planning consents and/or Construction Environmental Management Plans (CEMPs) will deal with expectations in relation to construction traffic for each site

separately. If any cumulative effects were to occur, this could only happen where planned site access routes on the wider transport network (outside site boundaries) overlap and if THC considers that there is potential for this between two or more sites then measures could be employed to address potential for increased construction traffic noise. It is anticipated that any cumulative effects of this nature would be managed through coordinated construction timelines to be approved by THC such that an appropriately staggered schedule can be ensured.

11.8 Decommissioning effects have not been assessed as detailed in **Chapter 2: Approach to the EIA**. They are however considered for the purpose of this chapter to be similar to those of construction effects in nature but are likely to be of shorter duration such that no significant effects are likely.

Infra-sound

11.9 Infra-sound is noise occurring at frequencies below that at which sound is normally audible, i.e. at less than about 20 hertz (Hz), due to the significantly reduced sensitivity of the ear at such frequencies. In this frequency range, for sound to be perceptible, it has to be at a very high amplitude and it is generally considered that when such sounds are perceptible then they can cause considerable annoyance.

11.10 Wind turbines have been cited by some as producers of infra-sound. This has, however, been due to the high levels of such noise, as well as audible low frequency thumping noise, occurring on older 'downwind' turbines of which many were installed in the USA prior to the large scale take up of wind power production in the UK. Downwind turbines are configured with the blades downwind of the tower such that the blades pass through the wake left in the wind stream by the tower resulting in a regular audible thump, with infra-sonic components, each time a blade passes the tower. Virtually all modern larger turbines are of the upwind design; that is with the blades upwind of the tower, such that this effect is eliminated.

11.11 A study into low frequency noise from wind farms¹ concluded that "infrasound noise emissions from wind turbines are significantly below the recognised threshold of perception for acoustic energy within this frequency range. Even assuming that the most sensitive members of the population have a hearing threshold which is 12 decibels (dB) lower than the median hearing threshold, measured infrasound levels are well below this criterion". It goes on to state that, based on information from the World Health Organisation, "there is no reliable evidence that infrasound below the hearing threshold produce physiological or psychological effects" and that "it may therefore be concluded that infrasound associated with modern wind turbines is not a source which may be injurious to the health of a wind farm neighbour".

11.12 A considerable amount of research has been conducted with regard to the levels of infrasound that wind turbines emit^{2,3,4}. Further reliable evidence^{5, 6} suggests that at typical residential distances (e.g. at 500 metres (m) or more), the levels of infrasound from a wind farm are significantly below accepted thresholds of perception. Even when measured in close proximity to a wind turbine, the measured levels of infrasound are still below accepted thresholds of perception. This suggests that infrasound is not an issue for neighbours in the vicinity of wind turbines.

Vibration

11.13 The ETSU study referenced at **Paragraph 11.12**² also found that vibration from wind turbines, as measured at 100m from the nearest machine, was well below the criteria recommended for human exposure in critical working areas such as precision laboratories⁷. At greater distances from turbines vibration levels are even lower. This was confirmed in a study by Keele University⁵, which showed vibration levels of around 10⁻⁸ms⁻² at a distance of 2.4 kilometres (km) from the Dun Law Wind Farm site under high wind conditions, orders of magnitude lower than the criteria for critical working areas referred to above which specify levels in the region of 0.005ms⁻². The LUBW report⁵, also referenced at **Paragraph 11.12**, provides further evidence that levels of vibration associated with the operation of larger wind turbines are also insignificant.

¹ DTI, 2006, The Measurement of Low Frequency Noise at Three UK Wind Farms

² ETSU W/13/00392/REP, Low Frequency Noise and Vibrations Measurement at a Modern Wind Farm, DTI, 1997

³ Microseismic and Infrasound Monitoring of Low Frequency Noise and Vibrations from Wind Farms, Styles et al, 2005

⁴ Measurement and Level of Infrasound from Wind Farms and Other Sources. 40(1). Acoustics Australia. Turnbull et al, April 2012

⁵ Low-frequency noise incl. infrasound from wind turbines and other sources, Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg (LUBW), 2016

⁶ Infrasound Does Not Explain Symptoms Related to Wind Turbines, VN TEAS - Prime Minister's Office, Finland, 2020

⁷ BS 6472-1, Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting. BSI, 2008

11.14 Vibration from onsite construction activities and during operation will not be perceptible at residential properties due to the large separation distance from the Proposed Development to neighbouring dwellings, the details of which are provided below. Vibration from construction vehicles accessing the Site may be perceptible at roadside properties but will be no greater than from other heavy good vehicles. Whilst this vibration may well be perceptible on occasion, it will not be of a level which would cause property damage of any description.

Amplitude Modulation

11.15 The variation in noise level associated with turbine operation, at the rate at which turbine blades pass any fixed point of their rotation (the blade passing frequency), is often referred to as blade swish and amplitude or aerodynamic modulation (AM) and is an inherent feature of wind turbine noise. This affect is identified within ETSU-R-97, where it is envisaged that "... modulation of blade noise may result in variation of the overall A-Weighted noise level by as much as 3dB(A) (peak to trough) when measured close to a wind turbine..." and that at distances further from the turbine where there are "... more than two hard, reflective surfaces, then the increase in modulation depth may be as much as 6dB(A) (peak to trough)".

11.16 It has been noted that complaints about wind farm noise have, in many cases, been specifically concerned with amplitude modulation. This is also apparent from ETSU-R-97, where it is noted that "it is the regular variation of the noise with time that, in some circumstances, enables the listener to distinguish the noise of the turbines from the surrounding noise". The modulation of noise may affect perceived annoyance for sounds with the same overall sound pressure level.

11.17 RenewableUK (RUK), the main renewable energy trade association in the UK, completed research into the causes and subjective effects of AM^{8,9,10,11} following various reports of increased levels of AM being experienced at dwellings neighbouring some wind turbine sites. This concluded that the predominant cause is likely to be from individual blades going in and out of stall as they pass through regions of higher wind speed at the top of their rotation under high wind shear conditions. Subjective tests carried out by Salford University, using loudness matching techniques, have demonstrated the extent to which higher levels of modulation depth result in increased perceived loudness.

11.18 This resulted in the inclusion of a mechanism to assess and regulate AM effects in the standard form of a condition^{12,13} frequently applied to wind farm developments as included in the IOA GPG. The IOA reviewed this mechanism and released a discussion document¹⁴ which reviews several different methods for rating amplitude modulation in wind turbine noise and subsequently released a recommended method¹⁵ by which to characterise the peak to trough level in any given 10-minute period.

11.19 Although this document provides a definitive approach for the quantification of AM, it does not provide any comment on what could be defined as an unacceptable level of AM nor any kind of penalty scheme, such as for tonal content, by which the overall turbine noise level should be corrected to account for its presence. This has subsequently been covered by a Department of Energy & Climate Change (DECC) commissioned project looking at human response to the amplitude modulated component of wind turbine noise¹⁶.

11.20 The combination of these two documents provides both a method of quantification of the level of amplitude modulation over a given 10-minute period and the appropriate penalty to apply where necessary. This is in addition to any penalty for tonal noise.

11.21 It should be noted that most wind farms operate without significant AM, and that it is not possible to predict the likely occurrence of AM, but, like tonal noise, AM can be covered by a suitably worded planning condition. One proposed wording for such a condition can be seen in an article jointly authored by a number of consultants working in the area in the November/December 2017 issue of the IOA's Acoustics Bulletin magazine¹⁷. Currently, AM is typically addressed in response to any complaints via a measurement scheme that refers to emerging best practice in this regard. In this instance, the Proposed Development is located far enough away from noise sensitive dwellings that any effect relating to AM from the Proposed Development is unlikely. Further reference as to a means by which AM may be addressed in practice is provided by the EHO dealing with the Proposed Development (see **Table 11.1**).

11.22 There are no standard or agreed methods by which to predict, with any certainty, the likelihood of AM occurring at a level requiring a penalty at a particular development, only some indicators such as relatively high wind shear conditions under certain circumstances or particular turbine designs and/or dimensions.

Cumulative Operational Noise Effects

11.23 The Scoping Report for the Proposed Development states that "Cumulative operational noise will not be considered where the Proposed Development is predicted to make a negligible contribution to cumulative noise level". In this case the Proposed Development is located nearly 5km from the nearest residential dwelling. As a result, operational noise levels will be well below the minimum noise criteria specified within ETSU-R-97 (see **Paragraph 11.35**) and the target noise level specified by representatives of THC (see **Table 11.1**). The operational noise assessment provided herein demonstrates that operational noise levels are more than 10 dB (an order of magnitude) below these minimum requirements. As a result, it is not considered necessary to consider other potential schemes in the area as the introduction of the Proposed Development would not make any significant contribution to the noise level at any of the neighbouring properties, in terms of relevant planning guidance.

Assessment Methodology

Legislation and Guidance

11.24 This assessment is carried out in accordance with the principles contained within the following documents:

- Planning Advice Note PAN1/2011: Planning and Noise¹⁸;
- Scottish Government 2014: Web Based Planning Advice, Onshore Wind Turbines¹⁹;
- ETSU-R-97: The Assessment and Rating of Noise from Wind Farms (1997)²⁰;
- Institute of Acoustics: A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (2013)²¹; and
- BS 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites²².

PAN1/2011, Planning and Noise

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

11.26 The accompanying Technical Advice Note to PAN1/2011, Assessment of Noise, lists BS 5228, Noise and Vibration Control on Construction and Open Sites as being applicable for Environmental Impact Assessment (EIA) and planning purposes.

Web Based Planning Advice, Onshore Wind Turbines

11.27 The web-based planning advice on onshore wind turbines states that the sources of noise are "the mechanical noise produced by the gearbox, generator and other parts of the drive train; and the aerodynamic noise produced by the passage of the blades through the air" and that "there has been significant reduction in the mechanical noise generated by wind turbines through improved turbine design". It states that "the Report, 'The Assessment and Rating of Noise from Wind Farms' (Final Report, Sept 1996, DTI), (ETSU-R-97), describes a framework for the measurement of wind farm noise, which should be followed by applicants and consultees, and used by planning authorities to assess and rate noise from wind energy developments, until such time as an update is available". It notes that "this gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable burdens on wind farm developers, and suggests appropriate noise conditions". The

⁸ Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect, RenewableUK, December 2013

⁹ Summary of Research into Amplitude Modulation of Aerodynamic Noise from Wind Turbines, Temple Group, December 2013

¹⁰ Review of RenewableUK's Research into Amplitude Modulation, Temple Group, December 2013

¹¹ Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effects - Brief Summary, RenewableUK, December 2013

¹² The Development of a Penalty Scheme for Amplitude Modulated Wind Turbine Noise: Description and Justification, Renewable UK, December 2013

¹³ Template Planning Condition on Amplitude Modulation: Noise Guidance Notes, RenewableUK, December 2013

¹⁴ Discussion Document on "Methods for Rating Amplitude Modulation in Wind Turbine Noise", IOA, 2015

¹⁵ A Method for Rating Amplitude Modulation in Wind Turbine Noise - Version 1, IOA, 2016

¹⁶ Wind Turbine AM Review: Phase 1 & Phase 2 Reports, DECC, 2016

¹⁷ Acoustics Bulletin Vol. 42 No. 6, A planning condition for wind turbines, McKenzie et al., Nov/Dec 2017

¹⁸ PAN1/2011, Planning and Noise, The Scottish Government, March 2011

¹⁹ Onshore Wind Turbines, Scottish Government, May 2014

²⁰ ETSU-R-97, The Assessment and Rating of Noise from Wind Farms, DTI, 1996

²¹ A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, Institute of Acoustics, May 2013

²² BS 5228 + A1, Code of Practice for Noise and Vibration Control on Construction and Open Sites, BSI, 2009 + 2014

document goes on to reference the good practice guide (GPG) document discussed below in terms of assessing noise associated with wind turbine developments.

11.28 It introduces the Institute of Acoustics (IOA) A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (GPG), and states that “*The Scottish Government accepts that the guide represents current industry good practice*”.

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

11.29 ETSU-R-97, The Assessment and Rating of Noise from Wind Farms, presents the recommendations of the Working Group on Noise from Wind Turbines, set up in 1993 by the Department of Trade and Industry (DTI) as a result of difficulties experienced in applying the noise guidelines existing at the time to wind farm noise assessments. The group comprised independent experts on wind turbine noise, wind farm developers, DTI personnel and local authority Environmental Health Officers. In September 1996 the Working Group published its findings by way of report ETSU-R-97. This document describes a framework for the measurement of wind farm noise and contains suggested noise limits, which were derived with reference to existing standards and guidance relating to noise emission from various sources.

11.30 ETSU-R-97 recommends that, although noise limits should be set relative to existing background and should reflect the variation of both turbine and background noise with wind speed, this can imply very low noise limits in particularly quiet areas. It states that in such cases “it is not necessary to use a margin above background in such low-noise environments. This would be unduly restrictive on developments which are recognised as having wider global benefits. Such low limits are, in any event, not necessary in order to offer a reasonable degree of protection to the wind farm neighbour”.

11.31 For day-time periods, the noise limit is 35-40dB LA90 or 5dB above the 'quiet daytime hours' prevailing background noise, whichever is the greater. The actual value within the 35-40dB LA90 range depends on the number of dwellings in the vicinity; the effect of the limit on the number of kWh generated; and the duration of the level of exposure.

11.32 For night-time periods the noise limit is 43dB LA90 or 5dB above the prevailing night-time hours background noise, whichever is the greater. The 43dB LA90 lower limit is based on a sleep disturbance criteria of 35dB(A) with an allowance of 10dB for attenuation through an open window and 2dB subtracted to account for the use of LA90 rather the LAeq (see **Paragraph 11.36**).

11.33 Where the occupier of a property has some financial involvement with the proposal, the day and night-time lower noise limits are increased to 45dB LA90 and consideration can be given to increasing the permissible margin above background. These limits are applicable up to a wind speed of 12 metres per second (m/s) measured at 10m height on the Site.

11.34 Quiet day-time periods are defined as evenings from 18:00-23:00 plus Saturday afternoons from 13:00-18:00 and Sundays from 07:00-18:00. Night-time is defined as 23:00-07:00. The prevailing background noise level is set by calculation of a best fit curve through values of background noise plotted against wind speed as measured during the appropriate time period with background noise measured in terms of LA90,t. The LA90,t is the noise level which is exceeded for 90% of the measurement period 't'. It is recommended that at least 1 weeks' worth of measurements is required.

11.35 Where predicted noise levels are low at the nearest residential properties a simplified noise limit can be applied, such that noise is restricted to the minimum ETSU-R-97 level of 35dB LA90 for wind speeds up to 10m/s at 10m height. This removes the need for extensive background noise measurements for smaller or more remote schemes.

11.36 It is stated that the LA90,10min noise descriptor should be adopted for both background and wind farm noise levels and that, for the wind farm noise, this is likely to be between 1.5 and 2.5dB less than the LAeq measured over the same period. The LAeq,t is the equivalent continuous 'A' weighted sound pressure level occurring over the measurement period t. It is often used as a description of the average noise level. Use of the LA90 descriptor for wind farm noise allows reliable measurements to be made without corruption from relatively loud, transitory noise events from other sources.

11.37 ETSU-R-97 also specifies that a penalty should be added to the predicted noise levels where any audible tone is present. The level of this penalty is described and is related to the level by which any tonal components exceed audibility.

11.38 With regard to multiple wind farms in a given area, ETSU-R-97 specifies that the absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area contributing to the noise received at the properties in

question. Existing wind farms should therefore be included in cumulative predictions of noise level for proposed wind turbines and not be considered as part of the prevailing background noise.

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

11.39 In May 2013, the IOA published A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise. This was subsequently endorsed by the Secretary of State for Energy and Climate Change. The publication of the Good Practice Guide (GPG) followed a review²³ of current practice carried out for the Department of Energy and Climate Change (DECC) and an IOA discussion document²⁴ which preceded the GPG.

11.40 The GPG includes sections on Context; Background Data Collection; Data Analysis and Noise Limit Derivation; Noise Predictions; Cumulative Issues; Reporting; and Other Matters including Planning Conditions; Amplitude Modulation; Post Completion Measurements; and Supplementary Guidance Notes. The Context section states that the guide “*presents current good practice in the application of the ETSU-R-97 assessment methodology for all wind turbine development above 50 kilowatts (kW), reflecting the original principles within ETSU-R-97, and the results of research carried out and experience gained since ETSU-R-97 was published*”. It adds that “*the noise limits in ETSU-R-97 have not been examined as these are a matter for Government*”.

11.41 As well as expanding on and, in some areas, clarifying issues which are already referred to in ETSU R-97, additional guidance is provided on noise prediction and a preferred methodology for dealing with wind shear.

BS 5228 Code of Practice for Noise and Vibration Control on Construction and Open Sites

11.42 This document provides example criteria for the assessment of the significance of construction noise effects and a method for the prediction of noise levels from construction activities.

Consultation

11.43 In undertaking the assessment, consideration has been given to the Scoping Responses and other consultation which has been undertaken as detailed in **Table 11.1**.

Table 11.1: Consultation Responses

Consultee and Date	Scoping/Other Consultation	Issue Raised	Response/Action Taken
THC 24 TH February 2021	Formal Scoping Response	Target noise levels are either a simplified standard of 35dB LA90 at wind speeds up to 10m/s or a composite standard of 35dB LA90 (daytime) and 38dB LA90 (night-time) or up to 5dB above background noise levels at up to 12m/s. The noise assessment must take into account the potential cumulative effect from any other existing or consented, or, in some cases, proposed wind turbine developments.	The operational noise assessment has been carried out with reference to the limits provided within ETSU-R-97 and the target levels specified by THC.
		Research has been carried out in recent years on the phenomenon of amplitude modulation arising from some wind turbine developments. However at this time, the IOA Good Practice Guide does not provide definitive planning guidance on this subject. That being the case, any complaints linked to amplitude modulation would be investigated in terms of the Statutory Nuisance provisions of the Environmental Protection Act 1990.	Amplitude modulation has been scoped out of the assessment (see Paragraphs 11.15 to 11.22 above).
		Given the location, construction noise at the turbine sites is highly unlikely to be an issue at any noise sensitive properties, however, consideration will need to be given to construction traffic.	A discussion is provided in relation to construction vehicle movements below.

Study Area

11.44 The study area is restricted to properties within an approximate radius of 10km from the proposed wind turbine locations as shown at **Figure 11.1** and the selected properties has been determined based on the Scoping layout for the Proposed Development.

²³ Report on DECC Research Contract 01.08.09.01/492A (Analysis), Analysis of How Noise Impacts are Considered in the Determination of Wind Farm Planning Applications, Department of Energy and Climate Change, 2011

²⁴ Discussion Document on “A Good Practice Guide to the Application of ETSU-R-97 for Wind Turbine Noise Assessment”, Institute of Acoustics, July 2012

11.45 The study area in respect of construction noise is restricted to properties that may be directly affected by construction vehicles passing along local roads or where the provision of access tracks/upgrades to local roads are required. The access route to the Proposed Development is provided at **Figure 11.1**.

Desk Based Research and Data Sources

11.46 The following data sources have informed the assessment:

- Ordnance Survey (OS) and aerial mapping;
- Topographical information; and
- Candidate turbine source noise levels for the Siemens-Gamesa SG155 AM 6.6 megawatts (MW) model.

Field Survey

11.47 A background/baseline noise survey is not considered necessary for the purposes of the operational noise assessment given the distance of the Proposed Development to neighbouring residential properties and the resultant low levels of operational noise which would easily meet the minimum planning requirements.

Assessing Significance

Sensitivity

11.48 All residential dwellings are considered to be equally sensitive to operational noise associated with the Proposed Development.

11.49 All residential dwellings are regarded as equally sensitive in respect of the effects relating to construction noise.

Magnitude

11.50 The magnitude of change has not been discussed here as ETSU-R-97 solely requires that overall turbine levels (including for the effect of other cumulative development) does not exceed certain limiting values which take into account the balance of the need for renewable energy and the protection of the noise environment at neighbouring properties.

11.51 The potential magnitude of effect in relation to construction effects is not relevant here as a pass/fail criteria is also applied in this respect.

Significance

11.52 There are no formal significance criteria for assessing operational noise from wind farms. However, for the purposes of this assessment the noise effect is considered to be not significant if the operational noise limits defined within ETSU-R-97, taking into account the requirements of the IOA GPG, are met and significant if not.

11.53 BS 5228 provides example criteria for the assessment of the significance of construction noise effects and a method for the prediction of noise levels from construction activities. Two example methods are provided for assessing significance. The first is based on the use of criteria defined in Department of the Environment Advisory Leaflet (AL) 72, Noise Control On Building Sites. The second is based on noise change but applies defined lower limiting criteria for certain night-time, evening and weekends, and daytime periods of 45, 55 and 65dB(A) respectively. The latter set of criteria are applicable when existing noise levels are low, which they are at the Proposed Development, and have a duration of one month or more. Construction noise is discussed in terms of these criteria and the effect is judged to be not significant if these criteria can be met and significant if not.

Assessment Limitations

11.54 The assessment provide herein is limited in respect of the candidate turbine source noise data used to inform the predictions. However, given the resultant low levels of operational noise and the margin between these low levels and minimum planning requirements it is considered that most, if not all, current and relevant turbine models could be installed at the Site with minimal resultant operational noise effects.

Existing Conditions

11.55 The existing baseline noise conditions are expected to be typical of a quiet/rural environment. The properties to the north of the Proposed Development may expect to experience road traffic noise from the nearby A831 and water flow noise from the River Enrick. The properties to the south will experience road traffic noise from the A887 and water flow noise from the River Moriston.

11.56 No measurements of background noise measurements have been carried out for this assessment as this is not considered necessary under the remit of ETSU-R-97. The shortest distance between the turbines comprising the Proposed Development and the nearest residential dwellings is over 5 km.

Implications of Climate Change

11.57 The effects of climate change are not expected to significantly affect the baseline conditions found at the Site. The generalised noise sources found at dwellings neighbouring the Site, as listed at **Paragraph 11.55**, will remain the same regardless. However, it is accepted that the effects of climate change may alter the timing of increased rainfall and the potential for relative drought during certain times of the year which, in turn, will affect the timing for which, higher or lower background noise levels should normally be expected without a change in climate.

Future Baseline in the Absence of the Proposed Development

11.58 Future baseline/background noise levels are not expected to change significantly in the absence of the Proposed Development. The noise sources found at dwellings neighbouring the Site, as listed at **Paragraph 11.55** are expected to remain the same in general terms.

Design Considerations

11.59 The Proposed Development is located sufficiently far from neighbouring dwellings for operational noise effects not to be a defining factor in the design of the Proposed Development. However, a number of layouts and the potential effect from other potential wind farm development in the area have been reviewed, including Bhlaraidh Wind Farm Extension (consented), Chrathaich (design/Scoping stage) and Fiodhag (design/Scoping stage) using layouts supplied by LUC, to determine whether cumulative noise effects have the potential to affect this.

Micrositing

11.60 The Proposed Development is located such that even reasonably large changes in turbine locations would not change the conclusions of the operational noise assessment provided herein, therefore the potential effects assessed below would remain valid for any changes to turbine locations within the 50m micrositing tolerance.

Good Practice Measures

11.61 In terms of operational noise generated by the Proposed Development, the candidate Siemens-Gamesa SG 6.6-155 AM 6.6 MW turbine considered here is understood to include for serrated trailing edge (STE) blade design which has the effect of reducing source noise levels when compared with standard turbine blades. Turbines of the size and scale considered for the Proposed Development typically include this feature as a matter of course, and it is expected that the actual turbine for potential installation at the Site, should planning consent be granted, will have similar blade design. Nevertheless, noise associated with the operation of the Proposed Development will be required to meet planning condition noise limits, regardless of the specific design of turbine.

11.62 Construction noise associated with the introduction of the Proposed Development will be minimised through the use of 'best practicable means' to minimise the level noise generated as part of these activities and with due regard to the relative sensitivity of the area for which construction noise and/or traffic is expected in terms of distance to neighbouring properties. This will include the restriction of certain activities to certain times, use of quiet working methods and use of further mitigation measures such as temporary barriers if necessary. Specific mitigation measures that may be required for certain activities will be detailed within a Construction Environmental Management Plan (CEMP) where necessary. Noise during construction works will be controlled by generally restricting works to standard working hours, which exclude Saturday afternoons and Sundays, unless specifically agreed otherwise. BS 5228 states that the 'attitude of the contractor' is important in minimising the likelihood of complaints and therefore providing information to residents on intended activities along with consultation with the local authorities will be required.

Assessment of Effects

Construction Effects

Predicted Construction Effects

11.63 The construction of the proposed turbines will occur at distances that are highly unlikely to result in noise levels that will breach typical construction noise limits prescribed within relevant guidance such as BS 5228 Code of Practice for Noise and Vibration Control on Construction & Open Sites (see **Paragraph 11.24**). This combined with the temporary nature of the works means that a detailed assessment of these construction noise effects is not considered necessary.

11.64 Intermittent construction effects related to access to the Proposed Development from the south of the Site may occur at dwellings neighbouring the access routes. Whilst the works in themselves will not result in expected breaches of required noise limits in relation to construction noise, provided that these works occur during daytime periods, heightened consideration of potential mitigation measures in the form of those specified within the Good Practice Measures section will be applied to maintain compliance with statutory requirements in this regard. Residents will also be informed as to the details of the works including expected timings and any particularly intense periods of vehicle movements that may occur.

11.65 There is the potential for certain turbine components to be delivered during night-time periods to minimise potential disruption on local roads. The times for potential delivery will be agreed with THC prior to these works being undertaken and residents neighbouring the route for which this may occur will be kept fully informed as to the relevant processes and timings in this respect.

11.66 In terms of the blasting within the proposed onsite borrow pit, the most appropriate mechanism to manage noise effects is for a pre-blasting noise management programme to be prepared which will identify the most sensitive receptors that could be potentially affected by blasting noise. However, given the large distance between the borrow pit and neighbouring residences, this may not be considered entirely necessary.

11.67 Overall, construction of the Proposed Development is expected to meet typical noise limits for activities of this type. As a result, this aspect is considered not significant. Nevertheless, 'best practicable means', as set-out above, will be used to minimise any potential disruption from these noise generating activities and both THC, and any local residents located near to access and/or affected by blasting works, will be kept informed as to the proposals and to progress in general.

Proposed Mitigation

11.68 No specific mitigation measures are proposed here as the specific plant, schedule and construction methods to be employed during construction are currently unknown. However, provided that the 'best practicable means' mitigation measures and community engagement is maintained on a typical basis for works of this type, it is highly likely that statutory noise limits can readily be met and potential concerns from localised residents can be alleviated as far as possible.

Residual Construction Effects

11.69 As discussed above, noise resulting from the construction of the Proposed Development is expected to meet typical noise limits for activities of this type without any specific mitigation being required. As a result, this aspect is considered not significant. Typical noise mitigation measures can be employed to absolutely ensure that all statutory requirements are met in this respect and the resultant effect is considered **not significant** as a result.

Operational Effects

Predicted Operational Effects

11.70 The predicted maximum noise levels associated with the operation of the Proposed Development have been calculated for a number of residential locations located within the study area identified at **Paragraph 11.44**. The predictions have been undertaken using the methodology specified in ISO 9613-2 *Acoustics - Attenuation of Sound During Propagation Outdoors*²⁵, as specified within the GPG and including all relevant assumptions that the GPG recommends, as summarised below:

- A receptor height of 4m;
- The application of 2dB of uncertainty to the candidate turbine source noise levels;
- Atmospheric absorption coefficients taken from ISO9613-1²⁶ and corresponding to a temperature of 10°C and a relative humidity of 70%. This gives relatively low levels of atmospheric attenuation and provides a conservative basis for assessment;
- An appropriate assumption in respect of 'ground effects' (G=0.5);
- Attenuation due to the topographical barriers has been calculated using VDI 2720 *Noise Control by Barriers Outdoors*²⁷. The relevant inputs, C₁, C₂ and C₃, account for the proportional attenuation effects associated with line of sight between the source and receiver, the relative path difference and the presence of any localised reflections near the barrier respectively. These factors have been calibrated, minimising the overall effect of each such that the resultant attenuation due to topography at neighbouring residences is limited to approximately 2dB where there is clearly no line of site between a turbine and the receptor, 5dB in situations where there is a significant topographical barrier between a particular turbine and a receptor and 10dB in exceptional situations where receptors are located relatively close to particularly large barriers such as tall cliff faces that obstruct any view between a receptor and a wind farm site. The results of a study of propagation of noise from wind farm sites carried out for ETSU²⁸ concluded that an attenuation of just 2dB(A) should be allowed where the direct line of site between the source and receiver is just interrupted and that 10dB(A) should be allowed where a barrier lies within 5m of a receiver and provides a significant interruption to the line of site.
- Where a 'concave ground profile' exists between a particular turbine and receptor location (i.e. the noise propagation path is across a valley or where the ground falls away significantly between the turbine and the receiver location) a 3dB addition to the predicted noise level in these instances, except where there is no line-of-sight from residences to the Proposed Development; and
- The overall calculated predicted turbine noise L_{Aeq} has been adjusted by subtracting 2dB to give the equivalent L_{A90} as suggested in ETSU-R-97 and reaffirmed within the GPG.

11.71 The source noise level used as part of the predictions is based on the maximum sound power level for the Siemens-Gamesa SG 6.6-155 AM 6.6MW turbine model, which is understood to have serrated trailing edges (STEs) installed on the blades. The sound power levels for the turbine model, as taken from specification documents provided by the manufacturer and including for the 2dB of uncertainty explained above, are shown at **Table 11.2** below.

Table 11.2: Source Noise Level

Turbine	Total, dB L _{WA}	Octave Band Centre Frequency (Hz)							
		63	125	250	500	1k	2k	4k	8k
Siemens-Gamesa SG 6.6-155 AM 6.6MW	107.0	86.6	94.0	98.6	100.9	100.7	101.0	94.4	79.4

11.72 The resultant predicted noise levels for a selection of dwellings located nearest to the Proposed Development are provided at **Table 11.3**. These 'Noise Sensitive Locations' (NSL) are illustrated on **Figure 11.1**.

Table 11.3: Maximum Predicted Noise Level

Location	Easting	Northing	Maximum Predicted Noise Level, dB L _{A90}	Location	Easting	Northing	Maximum Predicted Noise Level, dB L _{A90}
NSL1	240223	817735	19.9	NSL9	249363	825259	11.5
NSL2	240598	817265	18.7	NSL10	248813	827408	11.6

²⁵ ISO 9613-2, *Acoustics - Attenuation of Sound During Propagation Outdoors, Part 2: General Method of Calculation*, International Organization for Standardization, 1996
²⁶ ISO 9613-1, *Acoustics - Attenuation of sound during propagation outdoors, Part 1: Method of calculation of the attenuation of sound by atmospheric absorption*, International Organization for Standardization, 1992

²⁷ VDI 2720, *Noise control by barriers outdoors*, Verein Deutscher Ingenieure, 1997

²⁸ ETSU W/13/00385/REP, *A Critical Appraisal of Wind Farm Noise Propagation*, Department of Trade and Industry, 2000

Location	Easting	Northing	Maximum Predicted Noise Level, dB L _{A90}	Location	Easting	Northing	Maximum Predicted Noise Level, dB L _{A90}
NSL3	241268	817230	18.1	NSL11	245061	829681	14.6
NSL4	241568	817930	19.0	NSL12	244046	829834	15.7
NSL5	245678	819078	15.0	NSL13	241652	829599	18.8
NSL6	248216	823426	13.2	NSL14	240715	829630	19.7
NSL7	249037	824130	12.1	NSL15	237678	829968	20.1
NSL8	249432	824889	11.5	NSL16	231377	826959	17.4

11.73 The assessment indicates that operational noise levels associated with the Proposed Development will be at least 14dB below the lowest limiting requirements of ETSU-R-97 (see **Paragraph 11.35**).

11.74 The predictions assume that the wind turbine noise contains no audible tones. Where tones are present, a correction should be added to the measured or predicted noise level before comparison with the limits. The audibility of any tones can be assessed by comparing the narrow band level of such tones with the masking level contained in a band of frequencies around the tone called the critical band. The ETSU-R-97 noise limits require a tone correction to be applied to any derived turbine noise levels resulting from noise measurements of the operational turbines which depends on the amount by which the tone exceeds the audibility threshold. A warranty should be sought from the supplier of the turbine to ensure that no tonal penalty would be required in practice.

Proposed Mitigation

11.75 The Site is located such that predicted operational noise levels associated with the introduction of the Proposed Development will easily meet the limiting requirements of ETSU-R-97, without the need to curtail the operation of the turbines to reduce noise levels.

11.76 Suitably worded planning conditions are a common means to ensure that operational compliance measurements may be undertaken in the event of complaints relating to noise and appropriate recourse can then be sought by the Local Planning Authority should operational noise level exceed consenting requirements. Standard conditions will require that, should a complaint be received, appropriate monitoring takes place to determine whether specified noise limits are being adhered to and whether remedial measures are required to be put in place on that basis. However, in this instance, operational noise levels will be so low that they will be difficult or impossible to distinguish from other environmental noise sources via typical measurement practices.

Residual Operational Effects

11.77 The operational noise assessment indicates that predicted turbine noise levels, based on the installation of an appropriate candidate turbine, will meet the requirements of ETSU-R-97 without the requirement for mitigation/curtailment. Appropriate control measures can be put in place through the imposition of planning conditions which set the derived ETSU-R-97 noise limits. As a result, the noise effect associated with the operation of the Proposed Development is considered **not significant**.

Cumulative Effects during Construction

Predicted Cumulative Effects during Construction

11.78 There are a number of other proposed, consented and operational wind farm developments in the area including Bhlaraidh Wind Farm Extension (consented), Chrathaich (design/Scoping stage) and Fiodhag (design/Scoping stage), all of which will be set-back a sufficient distance from neighbouring dwellings such that any potential breaches of typical construction noise limits in terms of BS 5228 *Code of Practice for Noise and Vibration Control on Construction & Open Sites* (see **Paragraph 11.24**) would not occur. It is

expected that any relevant planning consents for the other potential developments would set-out specific requirements in terms of controls relating to construction noise where necessary. This often takes the form of further liaison with the Local Planning Authority and/or the Environmental Health Department and the provision of a Construction Environmental Management Plan (CEMP).

11.79 There may be additional intermittent construction traffic if the Proposed Development and other planned schemes are eventually built at the same time. However, resultant noise levels at dwellings neighbouring access routes would still not be expected to breach typical construction noise limits in this respect.

Proposed Mitigation

11.80 Due to the above, no further mitigation measures are prescribed other than that required in terms of 'best practicable means', potential further consultation with THC and community engagement.

Residual Cumulative Effects during Construction

11.81 Noise resulting from the construction of the Proposed Development at the same time as other construction activities are expected to meet typical limits without any specific mitigation being required. As a result, this aspect is considered **not significant**.
Cumulative Effects during Operation

Predicted Cumulative Effects during Operation

11.82 The Proposed Development has predicted noise levels that are more than 10dB below the minimum 35dB L_{A90} limiting requirements of ETSU-R-97. Other potential wind farm development in the area, as discussed at **Paragraph 11.78**, which are likely to be located much closer to residential dwellings would likely have noise levels that are significantly higher and the noise associated with operation of the Proposed Development would make no significant contribution to it in planning terms. As a result, this aspect has been scoped out, as discussed earlier in this chapter.

Proposed Mitigation

11.83 The Proposed Development will not have any significant contribution to overall turbine noise levels in planning terms. As such, no specific mitigation measures are required in this respect.

Residual Cumulative Effects during Operation

11.84 The Proposed Development will not have any significant contribution to overall turbine noise levels in planning terms and is considered **not significant** as a result.

Interrelationship between Effects

11.85 There are no known interrelationships between the noise effects associated with the Proposed Development and other disciplines considered within this EIA Report.

11.86 There is no specific consistent evidence of health effects occurring directly as a result of noise associated with the construction and operation of wind turbines. The latest guidance from the World Health Organisation²⁹ (WHO), published in 2018, makes a conditional recommendation that operational turbine noise should not exceed 45dB L_{den} in order to prevent health effects. However, the WHO report makes it clear that reference should be made to relevant country or district guidance in this respect. Under typical circumstances in the UK, following the ETSU-R-97 guidance results in noise levels that will be below the recommended WHO criteria.

Further Survey Requirements and Monitoring

11.87 Should the Proposed Development be granted consent it is expected that noise conditions will be attached to any consent that will require that operational noise not to exceed a certain level. In this case it is considered that a limiting level of 30dB L_{A90} at neighbouring residences would be entirely adequate to protect amenity, with actual operational noise levels being significantly lower than this. It is considered that, due to the very low levels of operational noise expected at neighbouring dwellings, routine noise monitoring is not undertaken. However, in the very unlikely event that complaints are received by the operator directly or via THC some form of investigation should take place.

²⁹ Environmental Noise Guidelines for the European Region, World Health Organization, 2018

Summary of Significant Effects

11.88 No significant noise effects have been identified as a result of the construction or operation of the Proposed Development. Predicted operational noise levels are predicted easily meet the limiting requirements of ETSU-R-97 without the requirement to apply mitigation or curtail particular turbines.