Chapter 13

Noise

SCOTTISHPOWER RENEWABLES

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13.1. Executive Summary

1. Hayes McKenzie Partnership Limited (HMPL) has undertaken an assessment of the potential noise levels resulting from the construction and operation of the proposed Earraghail Renewable Energy Development ('the proposed Development') on behalf of ScottishPower Renewables (SPR). The proposed Development comprises 13 wind turbines, a substation, ground mounted solar arrays, a battery energy storage system (BESS), ancillary services and associated infrastructure.

2. The assessment focussed on operational noise associated with the proposed wind turbines and this aspect is assessed with reference to relevant guidance in the form of ETSU-R-97, 'The Assessment and Rating of Noise from Wind Farms', and the best practice guidance published by the Institute of Acoustics, 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise' (GPG).

3. Predicted noise levels associated with the operation of the wind turbines, based on the installation of three different possible candidate wind turbine models, have been compared with the noise limits determined with reference to ETSU-R-97. This demonstrates that a range of potential turbine model could be installed at the Site whilst comfortably meeting planning requirements. However, the actual turbine to be used for the proposed Development would be the result of a future commercial tendering process.

4. The substation, ground mounted solar arrays, a BESS and ancillary services have a limited noise output and would be located sufficiently far, with limited (or no) visibility, from neighbouring residential properties to cause any impacts of any significance. As a result, these aspects will not result in any significant impacts, do not warrant a detailed assessment and have not been considered in any specific detail within this Chapter.

5. The construction impacts of the proposed Development are discussed with reference to BS5228 'Code of Practice for Noise and Vibration Control on Construction & Open Sites'. A detailed assessment is not provided as the relative distances from turbine construction activities and neighbouring properties will mean that potential noise and vibration levels will be well within example noise limits specified within BS5228.

6. The results of the noise assessment shows that predicted levels comfortably meet the minimum requirements of ETSU-R-97 and therefore, no specific mitigation is required. This noise impact is, therefore, determined to be not significant. As discussed at S**ection 2** of this Chapter, a detailed assessment of noise associated with the operation of proposed solar panels, BESS and ancillary services has not been provided as the impacts would not be significant.

7. Furthermore, construction noise and vibration levels at neighbouring dwellings are expected to meet typical requirements in this regard and no specific mitigation measures are considered to be required other than that deemed necessary under normal best practice.

13.2. Introduction

8. An assessment of the potential noise and vibration levels resulting from the construction and operation of the proposed Earraghail Renewable Energy Development ('the proposed Development'), located on the Kintyre Peninsula, is presented within this Chapter. The assessment has been undertaken by Mike Craven BSc, MIOA of Hayes McKenzie Partnership Limited (HMPL).

9. The assessment focuses on the operational noise associated with the wind turbines proposed as part of the proposed Development and has been carried out according to the recommendations of ETSU-R-97, The Assessment and Rating of Noise from Wind Farms, and the best practice guidance published by the Institute of Acoustics, 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 referred to within web-based planning guidance provided by the Scottish Government.

10. Noise limits for properties neighbouring the proposed Development have been derived from data obtained during a survey of background noise levels in the area, and corresponding on-site wind speeds, in accordance with ETSU-R-97. Two monitoring locations were chosen as representative of dwellings closest to the proposed Development.

11. Predictions of the noise levels associated with the operation of the proposed Development, based on the installation of three different candidate wind turbine models, have been compared with the noise limits determined as above.

12. The substation, ground mounted solar arrays, BESS and ancillary services have and limited noise output, and would be located sufficiently far, with limited (or no) visibility, from neighbouring residential properties to result in any significant impacts. As a result, these aspects will not result in any significant impacts, do not warrant a detailed assessment and have not been considered in any specific detail within this Chapter.

13. A discussion of the potential impacts relating to the construction and decommissioning of the proposed Development, including from possible blasting within the proposed borrow pits, is provided in terms of relevant guidance; BS5228 Code of Practice for Noise and Vibration Control on Construction & Open Sites. However, a detailed assessment is not provided as the relative distances from turbine construction activities and neighbouring properties will mean that potential noise and vibration levels are expected to be well within required limits in this regard. Details of the relevant working practices, traffic routes, and proposed working hours are described in **Chapter 3.**

14. There are no other planned, consented or operational schemes in the area that would result in any significant increases in operational turbine noise when considering any potential cumulative impacts. As a result, only the isolative noise impacts associated with the proposed Development have been considered here.

13.3. Legislation, Policy and Guidelines

13.3.1 PAN1/2011, Planning and Noise

15. Planning Advice Note PAN1/2011 (Scottish Government 2011) identifies two sources of noise from wind turbines; mechanical noise and aerodynamic noise. Paragraph 29 of PAN1/2011 states that *"good acoustical design and siting of turbines is essential to minimise the potential to generate noise".* It refers to the Scottish Government's 'online planning advice' on renewables technologies for onshore wind turbines.

16. The accompanying Technical Advice Note to PAN1/2011, Assessment of Noise, lists BS 5228, Noise and Vibration Control on Construction and Open Sites (see Paragraphs 25 to 27) as being applicable for Environmental Impact Assessment (EIA) and planning purposes.

13.3.2 The Scottish Government's Online Planning Advice, Onshore Wind Turbines

17. The online planning advice on onshore wind turbines (Scottish Government, 2014) 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 windfarm 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".*

18. 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".*

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

19. 'ETSU-R-97, The Assessment and Rating of Noise from Wind Farms (DTI, 1996)', 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 windfarm noise assessments. The group comprised independent experts on wind turbine noise, windfarm developers, DTI personnel and planning authority Environmental Health Officers (EHOs). 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 windfarm noise and contains suggested noise limits, which were derived with reference to existing standards and guidance relating to noise emission from various sources.

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

21. For day-time periods, the noise limit is 35-40 dB L_{A90} or 5 dB above the 'quiet day-time hours' prevailing background noise, whichever is the greater. The actual value within the 35-40 dB L_{A90} 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.

22. For night-time periods the noise limit is 43 dB L_{A90} or 5 dB above the prevailing night-time hours background noise, whichever is the greater. The 43 dB L_{A90} lower limit is based on sleep disturbance criteria of 35 dB(A) with an allowance of 10 dB for attenuation through an open window and 2 dB subtracted to account for the use of L_{A90} rather the L_{Aeq}.

23. Where the occupier of a property has some financial involvement with the proposal, the day and night-time lower noise limits are increased to 45 dB L_{A90} and consideration can be given to increasing the permissible margin above background. These limits would be applicable up to a wind speed of 12 m/s measured at 10 m height on the Site. However, this is not relevant to the proposed Development.

24. 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 $L_{A90,t}$. The $L_{A90,t}$ 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.

25. Where predicted noise levels are low at the nearest residential properties, a simplified noise limit can be applied, such that noise is restricted to a level of 35 dB L_{A90} for wind speeds up to 10 m/s at 10 m height. This removes the need for extensive background noise measurements for smaller or more remote schemes.

26. It is stated that the $L_{A90,10min}$ noise descriptor should be adopted for both background and windfarm noise levels and that, for windfarm noise, this is likely to be between 1.5 and 2.5 dB less than the L_{Aeq} measured over the same period. The $L_{Aeq,t}$ is the equivalent continuous 'A' weighted sound pressure level occurring over the measurement period 't'. It is often used as a description of the average noise level. Use of the L_{A90} descriptor, the level exceeded for 90% of the measurement period, for windfarm noise allows reliable measurements to be made without corruption from relatively loud, transitory noise events from other sources.

27. 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, as shown on page 10 of the executive summary, is described and varies according to the level by which any tonal components exceed audibility.

28. With regard to multiple windfarms 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 overall turbine noise received at the properties in question. Existing windfarms should therefore not be considered as part of prevailing background noise level and noise limits should be compared with cumulative predictions for proposed wind turbines operating in combination with existing sites. However, in this instance and at this time there are no other developments that would result in any cumulative operational noise effects.

13.3.4 A Good Practice Guide to the Application of ETSU-R-97

29. In May 2013, the Institute of Acoustics (IoA) published 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise' (IoA, 2013). This was subsequently endorsed by the Scottish Government. The publication of the Good Practice Guide (GPG) followed a review of current practice carried out for the Department of Energy and Climate Change (DECC, 2011) and an IoA discussion document which preceded the GPG (IoA, 2012).

30. 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 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"*.

31. 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 (see **Section 3.8** of this Chapter for further information).

13.3.5 BS 8233 Guidance on Sound Insulation and Noise Reduction for Buildings

32. British Standard (BS) 8233 (BSI, 2014) advises the use of ETSU-R-97 when assessing windfarm noise impact and states that reliable estimates of windfarm noise levels can be made by implementing the procedures set forth in the IOA GPG. It draws particular attention to the issues of amplitude modulation (AM); however, it goes on to state that such adverse effects cannot be predicted at the planning stage.

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

33. BS 5228:2009 + A1:2014 (BSI, 2009 + 2014) 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.

34. The first is based on the use of criteria defined in Department of the Environment Advisory Leaflet (AL) 72, Noise Control On Building Sites (DoE, 1976), which sets a fixed limit of 70 dB(A) in rural suburban and urban areas away from main roads and traffic. Noise levels are generally taken as façade L_{Aeq} values with free-field levels taken to be 3 dB lower giving an equivalent noise criterion of 67 dB L_{Aeq}.

35. The second is based on noise change but applies minimum criteria of 45, 55 and 65 dB L_{Aeq} for night-time (23:00-07:00), evening and weekends (19:00-23:00 weekdays, 13:00-23:00 Saturdays and 07:00-23:00 Sundays), and daytime (07:00-19:00) including Saturdays (07:00-13:00) respectively. These limits are applicable when existing noise levels are low, which they would be at the proposed Development Site, and have a duration of one month or more. It should be noted that the time period to which each limit applies also defines the time averaging period for the calculated L_{Aeq}.

13.3.7 Blade Swish (Amplitude Modulation of Aerodynamic Noise)

36. The variation in noise level associated with wind 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 3 dB(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 6 dB(A) (peak to trough)'*.

37. It has been noted that complaints to planning authorities regarding wind turbine noise in the UK, where they have occurred, have often 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.

38. RenewableUK (RUK), the main renewable energy trade association in the UK, completed research into the causes and subjective effects of AM (RUK, 2013) following various reports of increased levels of AM being experienced at dwellings neighbouring some wind turbine sites. This has 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 (RUK, 2013), using loudness matching techniques, have demonstrated the extent to which higher levels of modulation depth result in increased perceived loudness.

39. This resulted in the inclusion of a mechanism to assess and regulate AM effects in the standard form of a potential planning condition (RUK, 2013), which could be applied to windfarm developments in the same way as that included in the IoA GPG. The IoA reviewed this mechanism and released a discussion document (IoA, 2015) which reviews several different methods for rating amplitude modulation in wind turbine noise and subsequently released a recommended method (IOA, 2016) by which to characterise the peak to trough level in any given 10-minute period.

40. Although this document provides a definitive approach for the quantification of amplitude modulation, 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 noise (DECC, 2016).

41. 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.

42. It should be noted that most windfarms 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 Institute of Acoustics' Acoustics Bulletin magazine (McKenzie et al., 2017). Currently, AM is typically addressed in response to any complaints via a measurement scheme that refers to emerging best practice in this regard.

43. There are no standard or agreed methods by which to predict, with any certainty, the likelihood of amplitude modulation 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 for example.

13.3.8 Wind Shear

44. Wind shear, or more specifically vertical wind shear, is the rate at which wind speed increases with height above ground level. This has particular significance to wind turbine noise assessment where background noise measurements are referenced to measurements of wind speed at 10 metres height, which is suggested as appropriate by ETSU-R-97, but which is not representative of wind at hub-height, which is what affects the noise generated by the turbines.

45. The preferred method of accounting for wind shear in noise assessments is by referencing background noise measurements to hub height wind speed. Hub height wind speed may be determined directly by using a tall mast or remote sensing technology (i.e. LiDAR or SoDAR) or indirectly from measurements at a number of heights below hub height in order to calculate the hub height wind speed during the background noise survey period, as described in the GPG referred at **Section 3.4**. The hub height wind speeds are then converted to 'standardised 10 m wind speeds', assuming standardised conditions as used by turbine manufacturers when specifying turbine sound power levels.

13.3.9 Tonal Noise

46. ETSU-R-97 notes that, at the time the report was written, where complaints had been made over noise from existing windfarms, the tonal character of the noise from machinery in the nacelle had been the feature that had caused greatest annoyance. The recommendation was, therefore, that any assessment carried out should include a correction to the predicted noise levels according to the level of any tonal components in the noise. A specific tonal assessment methodology is described in the report which is based on the well-established 'Joint Nordic Method for the Evaluation of Tones in Broadband Noise' (DMoE, 1984) which has now been superseded by a revised version (Pederson et al., 1999) although this revision makes no substantive difference to the ETSU-R-97 methodology. A scale of corrections for tonal noise is included where the penalty is increased as the tone level increases above audibility to a maximum of 5 dB. The necessity of minimising tonal components in the noise output from the turbines is well understood by the turbine manufacturers and a guarantee should always be sought that any tonal noise will be below that requiring a penalty under the ETSU-R-97 scheme.

13.3.10 Infrasound

47. Infrasound is noise occurring at frequencies below that at which sound is normally audible, i.e. at less than about 20 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 of very high amplitude, and it is generally considered that when such sounds are perceptible then they can cause considerable annoyance.

48. Wind turbines have been cited by some as producers of infrasound. 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.

49. A study into low frequency noise from windfarms (ETSU/DTI, 2006) 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 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"*.

50. A considerable amount of research has been conducted in regard to the levels of infrasound that wind turbines emit (ETSU/DTI, 1997) (Styles et al., 2005) (Turnball et al., 2012). Further reliable evidence (LUBW, 2016) (VN TEAS, 2020) suggests that at typical residential distances (e.g. at 500 m or more), the levels of infrasound from a windfarm 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.

13.3.11 Low Frequency Noise

51. Noise from modern wind turbines is essentially broad band in nature in that it contains similar amounts of noise energy in all frequency bands from low to high frequency. As distance from a windfarm site increases, the noise level decreases as a result of the spreading out of the sound energy and also due to air absorption which increases with increasing sound frequency. This means that, although the energy across the whole frequency range is reduced, higher frequencies are reduced more than lower frequencies with the effect that as distance from the site increases the ratio of low to high frequencies also increases. This effect is not specific to wind turbines and may be observed with road traffic noise or natural sources, such as the sea, where higher frequency components are diminished relative to lower frequency components at long distances. At such distances, where residential properties are typically located in relation to windfarm developments, the overall noise level is so low, such that any bias in the frequency spectrum is insignificant.

13.3.12 Vibration

52. The ETSU study referenced at **Section 3.10** (DTI, 1997) found that vibration from wind turbines, as measured at 100 m from the nearest machine, was well below the criteria recommended for human exposure in critical working areas such as precision laboratories (BSI, 2008). At greater distances from turbines vibration levels are even lower. This has been confirmed by the Keele University study (Styles et al., 2005), which showed vibration levels of around 10^{-8} $m.s^{-2}$ at a distance of 2.4 km from the Dun Law Windfarm site under high wind conditions, orders of magnitude lower than the criteria referred to above which specify levels in the region of 0.005 $m.s^{-2}$. The LUBW report referred to at **Section 3.10** provides further evidence that levels of vibration associated with the operation of larger wind turbines are also insignificant.

13.3.13 Audibility

53. The potential audibility of noise from proposed wind turbines depends to a large extent on the amount by which the predicted turbine noise level exceeds the noise from other sources (the baseline or background noise level) and the presence of any acoustical 'features' which distinguish it. Such other noise may be steady and unchanging but is more likely to be continuously variable depending on the time of day and other factors including, particularly in rural areas, wind speed.

54. The results of baseline noise measurements carried out for the proposed Development are expressed in terms of the level exceeded for 90 % of each 10-minute interval which are shown plotted against wind speed on the assessment charts. The potential audibility of wind turbine noise from the proposed Development, for the quiet daytime and night-time hours and for worst case downwind propagation from the Site towards the various measurement locations, can be determined by comparing the predicted turbine noise with the measured background noise level for each 10-minute measurement period. Where predicted noise levels are around the same level as the background noise this suggests that the noise source may be just audible, with perceived audibility increasing with margin above background and also when taking into account any significant acoustic features such as tonality or amplitude modulation. Similarly, where predicted noise levels are lower than the existing background noise levels, audibility decreases with margin below other background noise.

13.3.14 Sleep Disturbance

55. The potential for sleep disturbance depends on the average and maximum levels of noise in sleeping areas during the night-time period. The night-time noise limits in ETSU-R-97 aim to protect against sleep disturbance by limiting the amount of wind turbine noise external to dwellings assuming a worst case of inhabitants sleeping with the windows open for ventilation. The internal noise levels in such circumstances can be calculated by assuming a 10-15 dB reduction in noise from outside to inside. The World Health Organisation (WHO) published recommendations in 1999 to the effect that average night-time noise levels in sleeping areas should not exceed 30 dB L_{Aeq} (WHO, 1999). Although this figure relates to overall noise level in sleeping areas, the potential for sleep disturbance specifically from turbine noise, for worst case downwind propagation with windows open, can be evaluated for each dwelling by subtracting 10-15 dB from the predicted turbine noise level and comparing with this criterion, after also adding 2 dB to convert the predicted turbine noise level to an L_{Aeq} value.

56. It should be noted that guidance from the WHO on night noise levels, in the form of the ‘Night Noise Guidelines for Europe’ (WHO, 2009), recommends that the population is not exposed to average external night-time noise levels, over a whole year, of more than 40 dB L_{Aeq}. This average yearly noise level will depend on the variation in wind speed, wind direction and noise from other sources over each year period.

57. Further to the above, the latest guidance from the WHO (WHO, 2018) conditionally recommends that turbine noise should not exceed an L_{den} of 45 dB. L_{den} is the average noise level over one year, where noise during evening and night-time periods is penalised with a 5 and 10 dB correction respectively. In the case of wind turbine noise, which is continually varying from

day to day, depending on the wind speed and direction, it will be almost impossible to establish compliance with this limit through measurement alone.

58. It should also be noted that potential difficulty in getting to sleep, either at the start of the night or once awoken by other sources, may be more related to audibility indoors under specific circumstances (see **Section 3.13** above) than by average noise level.

13.4. Consultation

59. **Table 13.1** summarises the consultation responses and how these are considered in this Chapter.

Table 13.1: Consultee Response

Consultee	Summary of Key Issues	How this is addressed in this Chapter
Argyll and Bute Council (A&BC) – Scoping Report (April 2020) & Response (June 2020)	General approach presented as to the proposed approach to background noise monitoring; the general methodology for the assessment; the level of construction noise assessment to be provided; cumulative operational assessment, and the operational noise limits that are to be put forward in terms of the noise impacts associated with the proposed Development, as provided within this Chapter. A&BC had no specific concerns, only highlighting typical information to be presented in certain instances.	The assessment has been conducted as proposed in the scoping report.
Argyll and Bute Council (A&BC) Environmental Health Officer – Letter Regarding Approach and Baseline Noise Monitoring Proposals (February 2021) & Response (February 2021)	General approach presented as to the scope and approach to the operational noise impact assessment provided here including proposals for baseline noise monitoring locations. No specific concerns raised and agreement as to the baseline/background noise monitoring locations presented in this Chapter was provided.	The assessment has been conducted as proposed in the letter.

13.5. Assessment Methodology and Significance Criteria

13.5.1 Operational Assessment Methodology

60. The assessment of the noise levels associated with the proposed Development have been undertaken in accordance with ETSU-R-97 and the GPG (i.e., via the comparison of derived noise limits with predicted operational noise levels at neighbouring dwellings). There are no wind turbine developments in the vicinity of the proposed Development that would result in combined operational noise effects or cumulative effects of any relevance. **Table 13.2** shows the co-ordinates of the receptors considered within this Chapter.

Table 13.2: Assessment Locations

Location	Easting	Northing
Cnoc na Sgratha	192168	659819
Culindrach Farm	191904	659408
Monybachach	190495	658178
Coalfin	189728	658172
Skipness	190019	657761
Gartavaich	185944	658945
Glenreasdell Mains	186420	658429
Bruiland	186691	658158

61. Construction noise (including forestry felling) has been discussed in general terms and with due regard to typical guidance on this matter.

13.5.2 Operational Noise Prediction Methodology

62. Noise predictions have been carried out using International Standard ISO 9613, 'Acoustics - Attenuation of Sound During Propagation Outdoors'. The propagation model described in Part 2 of this standard (ISO, 1996) provides for the prediction of sound pressure levels based on either short-term downwind (i.e. worst case) conditions or long-term overall averages. In this case only the former has been considered.

63. The ISO propagation model calculates the predicted sound pressure level by taking the source sound power level for each turbine in separate octave bands and subtracting a number of attenuation factors according to the following:

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

64. These factors are discussed in detail below. The predicted octave band levels are summed together to give the overall 'A' weighted predicted sound level.

65. The turbine co-ordinates used for the assessment have been provided by SPR and are shown at **Table 13.3** below for ease of reference.

Table 13.3: Turbine Co-ordinates

Turbine	Easting	Northing
T1	187956	662033
T2	190341	662135
T3	190737	660952
T4	190110	661402
T5	189963	660645

Turbine	Easting	Northing
T6	190711	661790
T7	187801	662725
T8	188481	662728
T9	189075	662686
T11	190073	662403
T12	189156	662083
T13	188515	661414
T14	188473	660921

13.5.2.1 L_W - Source Sound Power Level

66. The sound power level of a noise source is normally expressed in dB re:1pW. The exact model of wind turbine to be used at the Site will be the result of a future tendering process and therefore, three indicative turbine models have been assumed for this noise assessment, as listed below and as provided by the respective manufacturers. The three candidate turbines are typical of the type and size of the turbine which may be considered for this Site, and assuming worst case downwind propagation.

67. Noise predictions for the proposed Development are based on the sound power levels of the following candidate turbines;

- Vestas V150 5.6 MW with serrated trailing edge (STE) blade modifications and a hub height of 105 m;
- Siemens-Gamesa SG155 6.0 MW AM turbine with a hub-height of 102.5 m; and
- Nordex N149 5.7 MW STE turbine with a hub height of 105 m.

68. The sound power levels for the turbine model are taken from specification documents provided by each of the manufacturers with 2 dB added to account for uncertainty. As such, the assumed sound power levels are likely to be comparable to a declared sound power level i.e. derived according to the methodology detailed within IEC 61400-14 (IEC, 2005).

69. The source noise data for the V150 and SG155 turbines is referenced to wind speeds experienced at the hub-height of the turbine. For consistency, the data has been converted to reference standardised 10 m height wind speeds in accordance with procedures defined within IEC-61400-11 (IEC, 2012).

70. **Table 13.4** provides the overall source noise levels used for the noise predictions, including for the uncertainty and, where necessary, taking into account the conversion from hub-height to standardised wind speeds, explained above.

Table 13.4: Turbine Source Sound Power Levels, dB LWA

Turbine	Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
SG155 AM	95.0	99.9	104.7	107.0	107.0	107.0	107.0	107.0	107.0	107.0
N149 STE	96.0	97.2	101.8	106.2	107.6	107.6	107.6	107.6	107.6	107.6
V150 STE	94.4	98.2	102.8	105.6	106.9	106.9	106.9	106.9	106.9	106.9

71. The octave band noise spectrums used for the noise predictions are shown in **Table 13.5**. The data for the turbine models is based on further information obtained from each of the manufacturers, normalised to the maximum sound power level for the unrestricted mode of operation associated with each model.

Table 13.5: Octave Band Noise Spectra, dB LWA

Turbine	Total, dB L_{WA}	Octave Band Centre Frequency (Hz)							
		63	125	250	500	1k	2k	4k	8k
SG155 AM	107.0	86.6	94	98.6	100.9	100.7	101.0	94.4	79.4
N149 STE	107.6	89.0	95.5	99.2	101.3	102.6	100.8	91.2	83.3
V150 STE	106.9	87.6	95.4	100.2	102.1	100.9	96.8	89.7	79.6

72. The predictions provided assume that the wind turbine noise contains no audible tones. Where tones are present, a correction is 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 will be sought from the supplier of the turbines to be installed at the site to help to ensure that no tonal penalty would be required in practice.

13.5.2.2 D - Directivity Factor

73. The directivity factor allows for an adjustment to be made where the sound radiated in the direction of interest is higher than that for which the sound power level is specified. In the case of wind turbines, the sound power level is measured in a downwind direction, corresponding to the worst case propagation conditions considered here and needs no further adjustment.

13.5.2.3 Ageo - Geometrical Divergence

74. The geometrical divergence accounts for spherical spreading in the free-field from a point sound source resulting in an attenuation depending on distance according to:

$$A_{geo} = 20 \times \log(d) + 11$$

where, d = distance from the turbine

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

13.5.2.4 Aatm - Atmospheric Absorption

76. The atmospheric absorption accounts for the frequency dependant linear attenuation with distance over the frequency spectrum according to:

$$A_{atm} = d \times \alpha$$

where, α = the atmospheric absorption coefficient for the relevant frequency band

77. Published values of 'α' from ISO9613 Part 1 (ISO, 1992) have been used, corresponding to a temperature of 10ºC and a relative humidity of 70%, which give relatively low levels of atmospheric attenuation, as given at **Table 13.6**. This provides a conservative basis for assessment.

Table 13.6: Atmospheric Absorption Coefficients

Octave Band Centre Frequency (Hz)	63	125	250	500	1k	2k	4k	8k
Atmospheric Absorption Coefficient (dB/m)	0.0001	0.0004	0.0010	0.0019	0.0037	0.0097	0.0328	0.1170

13.5.2.5 Agr - Ground Effect

78. Ground effect is the interference of sound reflected by the ground interfering with the sound propagating directly from source to receiver. The prediction of ground effects is inherently complex and depends on the source height, receiver height,

propagation height between the source and receiver and the ground conditions. The ground conditions are described according to a variable 'G' which varies between 0 for 'hard' ground (includes paving, water, ice, concrete and any sites with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation). The GPG recommends that the use of G = 0.5 and a receptor height of 4 m in rural areas are appropriate assumptions for the determination of noise emission levels at receptor locations downwind of wind turbines, provided that an appropriate margin for uncertainty has been included within the source levels for the proposed turbine. Accordingly, predictions provided here are based on G = 0.5 with a receptor height of 4 m.

13.5.2.6 Abar - Barrier Attenuation

79. The effect of any barrier between the noise source and the receiver position is that noise will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the noise. The barrier attenuations predicted by the ISO 9613 model have, however, been shown to be significantly greater than that measured in practice under downwind conditions. The results of a study of propagation of noise from windfarm sites carried out for ETSU (DTI, 2000) concludes that an attenuation of just 2 dB(A) should be allowed where the direct line of site between the source and receiver is just interrupted and that 10 dB(A) should be allowed where a barrier lies within 5 m of a receiver and provides a significant interruption to the line of site. However, there appears to be no significant barriers between the proposed Development and the neighbouring dwellings. As a result, this has not been accounted for within the predictions, with no barrier attenuation being assumed.

13.5.2.7 Amisc - Miscellaneous Other Effects

80. ISO 9613 includes effects of propagation through foliage and industrial plants as additional attenuation effects. The attenuation due to foliage has not been included here and any such effects are unlikely to significantly reduce noise levels below those predicted.

13.5.3 Concave Ground Profile

81. Studies have shown that sound propagation across a valley or 'concave ground profile' can result in noise levels which are higher than predicted due to a reduced ground effect and/or the focussing effect of the ground shape. Calculating the precise effect of this phenomenon is particularly difficult. However, a simplified approach to allow for it has been suggested in the GPG. Paragraph 4.3.9 in the GPG states that 'A further correction of +3 dB (or +1.5 dB if using G=0.0) should be added to the calculated overall A-weighted noise level for propagation "across a valley", i.e. a concave ground profile, or where the ground falls away significantly, between the turbine and the receiver location. The following criterion of application is recommended:

$$h_m \geq 1.5.(abs\ (h_s - h_r)/2)$$

where, h_m is the mean height above the ground of the direct line of sight from the receiver to the source (as defined in ISO 9613-2, Figure 3), and h_s and h_r are the heights above local ground level of the source and receiver respectively.'

82. The GPG states that *"Care needs to be exercised when evaluating this condition, as small changes in distances and height may trigger (or not) the criterion when the actual situation has not changed significantly"*. It is also evident that the criterion may also be triggered in situations where there is more than one valley between a particular source and receiver, where, in reality the stated causes of the 'concave ground profile' effect could not occur.

83. The topography between the proposed turbines and the dwellings considered here has been reviewed via inclusion of a digital terrain map (DTM) within the prediction model. This concludes that the ground profile between the proposed Development and the neighbouring receptors would not result in the condition above being triggered as there clearly is no overall concave topography. As a result, no corrections to the predicted noise levels are required in this regard.

13.5.4 Significance Criteria

84. There are no formal significance criteria for assessing noise from windfarms. However, for the purposes of this assessment the noise impact is considered to be not significant if the limits discussed in **Section 3.3** are met and significant if not.

85. The significance criteria for construction noise are taken from the example 'ABC Method' specified within BS5228. Table 13.7 below shows the relevant criteria for various time periods for the instance where background noise levels are low (see **Section 3.6**) as is the case for the proposed Development.

Table 13.7: Construction Noise Significance Criteria

Time Period	Limiting Value, dB L_{Aeq}
Night-time (23:00 – 07:00)	45
Evenings and Weekends (19.00–23.00 Weekdays, 13.00–23.00 Sat & 07.00–23.00 Sun)	55
Daytime (07.00−19.00) and Saturdays (07.00−13.00)	65

86. Construction noise is assessed against these adopted and the impact is therefore judged to be not significant if they are expected to be met.

13.6. Baseline Conditions

87. A background noise survey was carried out, as the first stage of the assessment procedure. Two dwelling locations were chosen based on a preliminary turbine layout. The measurement data has used as representative of all dwellings located closest to the proposed Development.

88. The survey was undertaken over the period from 5th to the 26th August 2021. Photos of the measurement locations are provided within **Figure 13.1**.

13.6.1 Noise Measurement Positions

89. A description of each of the monitoring locations is provided at **Sections 6.1.1 & 6.2.2** below.

13.6.2 Culindrach Farm

90. This dwelling is located to the southeast of the proposed Development. The noise monitoring equipment was installed near to the property, greater than 3.5 m from the nearest building facade and on the side of the house facing the proposed turbines in a sheltered area which minimised the potential for the measurements to be affected by the potential formation of streams. Noise sources noted during installation and removal of the equipment included the pattering of rain, noise from the sea, wind in the trees and foliage, various sea craft, activities around the dwelling and birdsong.

13.6.3 Monybachach

91. This property is located to the south of the proposed Development. The noise monitoring equipment was installed within the garden of the property, greater than 3.5 m from the nearest building facade and with a potential view of the turbines to be installed as part of the proposed Development. Noise sources noted during installation and removal of the equipment included farm works, building works on nearby dwellings, birdsong, dogs barking, pattering of rain, wind in the trees and foliage and faint noise from the sea.

13.6.4 Instrumentation

92. The background/baseline noise measurements were made with Larson Davis model LD-820 Sound Level Meters fitted with 1/2” microphones which comply with the Type 1 standard in IEC 651-1:1979 (IEC, 1979). The microphones were fitted with 45 mm radius foam ball windshields surrounded by 125 mm radius secondary windshields of 40 mm thickness, based on recommended design specifications within ETSU W/13/00386/REP, Noise Measurements in Windy Conditions (ETSU/DTI, 1996), and mounted on tripods at a height of approximately 1.2 to 1.5 metres height. Pre-calibration and post calibration checks were carried out using a Brüel & Kjær acoustic calibrator (s/n 3009009).

93. Concurrent onsite wind data was obtained from an existing meteorological mast with cup anemometers installed at 91, 80, 60 and 30 m height and a wind vane installed at a height of 80 m.

94. Pluvimate rain gauges were installed at both measurement locations.

13.6.5 Measurement Procedure

95. The meters were programmed to measure a number of statistical noise indices, including the L_{A90}, together with the maximum and minimum levels and the L_{Aeq} over consecutive 10-minute intervals. The equipment was synchronised to a Global Positioning System (GPS) time signal and the results were automatically stored at the end of each interval.

96. Calibration of the noise measurement equipment was carried out before the monitoring commenced and was checked at the end. A change of no more than 0.1 dB was noted at either of the measurement locations, which is within normal tolerances.

97. Wind shear has been addressed by relating background noise measurements to 105 m height wind speed (the approximate maximum hub height of the proposed turbines), determined from the wind speed measured at 91 and 80 m height above ground level and based on instantaneous wind shear exponent, α, for each period, as derived from the expression:

$$\frac{V_1}{V_2} = \left(\frac{h_1}{h_2}\right)^{\alpha},$$

where, h_1 and h_2 are the respective heights at which wind speeds V_1 and V_2 were measured.

98. The hub height wind speed has been corrected to 'standardised' 10 m height wind speed using the same methodology as is used by manufacturers to quantify sound power level data as required by IEC 61400-11 (IEC, 2012) and as detailed within the GPG, i.e.:

$$V_{10} = V_h \left(\frac{\ln\left(\frac{10}{z_0}\right)}{\ln\left(\frac{h_h}{z_0}\right)} \right),$$

where, V_{10} and V_h are the 'standardised' 10m height and hub height (h_h) wind speeds respectively, and z_0 is the reference ground roughness length (=0.05 m). In this way, it is ensured that the comparisons of predicted turbine noise level and background level (including any associated noise limits) are made on a like-for-like basis.

99. Rainfall data was taken from the installed rain gauges, which both logged rainfall in 10-minute intervals, time synchronised to a GPS time signal. This allows for corresponding data, where noise levels may be affected by the presence of rainfall, to be removed from the analysis.

13.6.6 Results of Measurements

100. The noise, wind and rain data collected during the measurement campaign, as detailed above, is shown as daily histograms within **Figure 13.2**.

101. Prevailing background noise levels during the night-time and quiet day-time hours, defined within ETSU-R-97, have been derived by plotting the measured L_{A90} background noise levels against the standardised 10 m height wind speeds as described within ETSU-R-97 and the GPG and shown within **Figure 13.3**.

102. Any 10-minute period where rainfall was recorded at either of the measurement locations is shown with dark blue circles and has been removed from the derivation of the prevailing background noise levels from the data collected at all the measurement locations. Other atypical or extraneous noise levels have also been removed from the analysis the measurement locations and these are identified with green circles.

103. Data collected on the night of the 20th August and in to the early hours of the 21st August at Culdrinach has been removed due to the influence of noise from a party that occurred during this time at the property, as noted by the resident.

104. Third order regression lines have been calculated through the background noise data for each time period at each measurement location to give the prevailing background noise data as required for the derivation of the ETSU-R-97 limits.

105. **Figure 13.3** shows the prevailing background noise levels for the two measurement locations and for the two time periods suggested within ETSU-R-97 over a range of wind speeds. **Table 13.8** shows these in tabular form. Where there is limited or no data on which to base the regression curve (i.e. at higher wind speeds) then background noise levels are assumed to remain at the level corresponding to the highest wind speed for which data is available.

Table 13.8: Prevailing Background Noise Levels, dB LA90

Location	Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Quiet Daytime										
Culindrach Farm	22.4	24.5	26.8	29.0	30.9	32.3	32.8	32.8	32.8	32.8
Monybachach	26.9	28.7	30.9	33.2	35.2	36.7	37.4	37.4	37.4	37.4
Night-time										
Culindrach Farm	21.8	23.3	25.0	27.0	29.0	31.3	33.7	33.7	33.7	33.7
Monybachach	25.3	26.9	29.0	31.5	34.3	37.2	40.2	40.2	40.2	40.2

106. **Table 13.9** shows the corresponding lower daytime, upper daytime and night-time noise limits (see **Section 3.3**) associated with the collected measurement information and associated data filtering.

Table 13.9: Noise Limits, dB LA90

Location	Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Lower Daytime										
Culindrach Farm	35.0	35.0	35.0	35.0	35.9	37.3	37.8	37.8	37.8	37.8
Monybachach	35.0	35.0	35.9	38.2	40.2	41.7	42.4	42.4	42.4	42.4
Upper Daytime										
Culindrach Farm	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
Monybachach	40.0	40.0	40.0	40.0	40.2	41.7	42.4	42.4	42.4	42.4
Night-time										
Culindrach Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
Monybachach	43.0	43.0	43.0	43.0	43.0	43.0	45.2	45.2	45.2	45.2

107. The Monybachach results have been used to represent that specific property and the Culrinach results are used to represent all other dwellings. This is considered to provide a conservative basis for assessment as other properties are located closer to the coast or have substantial tree cover surrounding them which would be expected to result in higher noise levels with increasing wind speed.

13.7. Potential Effects

13.7.1 Operational Noise

108. **Figure 13.4** shows an initial assessment of the predicted turbine noise levels assuming that all the dwellings considered here are downwind of all turbines simultaneously and that turbines to be installed as part of the proposed Development are operating unrestricted. The predicted turbine noise L_{Aeq} has been adjusted by subtracting 2 dB to give the equivalent L_{A90} as suggested in ETSU-R-97 and reaffirmed within the GPG.

109. **Table 13.10** shows the predicted noise levels associated with the proposed Development operating in isolation for reference. The actual turbine to be used for the proposed Development would be the result of a future commercial tendering process and the turbine models referenced below are provided to give an indication of the range of potential turbine models that could be installed at the Site.

110. A comparison of the levels shown at **Table 13.10** with the limits at **Table 13.9** (as provided within **Figure 13.2**) shows that predicted levels of operational noise are comfortably below the minimum criteria prescribed within ETSU-R-97.

Table 13.10: Predicted Operational Noise Levels, dB LA90

Location	Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
Vestas V150 5.6 MW STE										
Cnoc na Sgratha	18.4	22.2	26.8	29.6	30.9	30.9	30.9	30.9	30.9	30.9
Culindrach Farm	17.9	21.7	26.3	29.1	30.4	30.4	30.4	30.4	30.4	30.4
Monybachach	15.8	19.6	24.2	27.0	28.3	28.3	28.3	28.3	28.3	28.3
Coalfin	16.0	19.8	24.4	27.2	28.5	28.5	28.5	28.5	28.5	28.5
Skipness	14.6	18.4	23.0	25.8	27.1	27.1	27.1	27.1	27.1	27.1
Gartavaich	13.7	17.5	22.1	24.9	26.2	26.2	26.2	26.2	26.2	26.2
Glenreasdell Mains	13.5	17.3	21.9	24.7	26.0	26.0	26.0	26.0	26.0	26.0
Bruiland	13.3	17.1	21.7	24.5	25.8	25.8	25.8	25.8	25.8	25.8
Siemens-Gamesa SG155 6.0 MW AM										
Cnoc na Sgratha	17.7	22.6	27.4	29.7	29.7	29.7	29.7	29.7	29.7	29.7
Culindrach Farm	17.2	22.1	26.9	29.2	29.2	29.2	29.2	29.2	29.2	29.2
Monybachach	15.0	19.9	24.7	27.0	27.0	27.0	27.0	27.0	27.0	27.0
Coalfin	15.2	20.1	24.9	27.2	27.2	27.2	27.2	27.2	27.2	27.2
Skipness	13.8	18.7	23.5	25.8	25.8	25.8	25.8	25.8	25.8	25.8
Gartavaich	12.9	17.8	22.6	24.9	24.9	24.9	24.9	24.9	24.9	24.9
Glenreasdell Mains	12.7	17.6	22.4	24.7	24.7	24.7	24.7	24.7	24.7	24.7
Bruiland	12.5	17.4	22.2	24.5	24.5	24.5	24.5	24.5	24.5	24.5
Nordex N149 5.7 MW STE										
Cnoc na Sgratha	19.0	20.2	24.8	29.2	30.6	30.6	30.6	30.6	30.6	30.6
Culindrach Farm	18.6	19.8	24.4	28.8	30.2	30.2	30.2	30.2	30.2	30.2
Monybachach	16.4	17.6	22.2	26.6	28.0	28.0	28.0	28.0	28.0	28.0
Coalfin	16.6	17.8	22.4	26.8	28.2	28.2	28.2	28.2	28.2	28.2
Skipness	15.2	16.4	21.0	25.4	26.8	26.8	26.8	26.8	26.8	26.8
Gartavaich	14.3	15.5	20.1	24.5	25.9	25.9	25.9	25.9	25.9	25.9
Glenreasdell Mains	14.1	15.3	19.9	24.3	25.7	25.7	25.7	25.7	25.7	25.7
Bruiland	13.9	15.1	19.7	24.1	25.5	25.5	25.5	25.5	25.5	25.5

13.7.2 Construction Noise

111. The construction and decommissioning of the proposed turbines will occur at distances and times that are highly unlikely to 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 **Sections 3.6 & 5.3** of this Chapter for further information). This combined with the temporary nature of the works means that a detailed assessment of the construction noise impacts is not considered necessary. Furthermore, it is not expected that upgrades to local roads and provision of additional tracks relating to construction would occur in close proximity to neighbouring dwellings. As a result, this aspect of the proposed Development is considered not significant (see **Section 5.3**).

112. An additional construction noise impact would be blasting associated with the proposed stone extraction from borrow pits in order to obtain materials for the construction of turbine bases and access roads. This type of noise does not typically fall within the assessment of normal construction noise because of the extremely high amplitude and impulsive nature of the waveform. It is very likely that blasting noise could be heard at nearby residential locations, but a construction noise assessment would average noise levels across the day and is therefore not applicable to use for the assessment of blasting noise impacts. Mitigation to reduce the noise impact from blasting activities is set out in **Section 9.2**.

113. Where highways upgrades and cabling between the site and grid connection is carried out close to residential properties, there may be temporary short-term noise impacts, with the level of impact dependant on the specific work required. It is likely, however, that noisy activities near residential properties will generally continue for less than one month, and therefore this short-term noise impact can be considered not significant.

13.8. Cumulative Assessment

13.8.1 Operational Noise

114. There are no other proposed, operational or consented wind turbine developments in the vicinity of the proposed Development that would result in any significant increase in overall turbine noise levels. As a result, this is considered not significant.

13.8.2 Construction Noise

115. A planning application for a borrow pit nearby to the proposed Development has been submitted by Balfour Beatty. This borrow pit is expected to have typical noise control measures associated with development of this kind (see **Section 9.3** of this Chapter) and its use is not expected to occur at the same time as the borrow pit proposed as part of the proposed Development. However, if they were used simultaneously, the relevant noise control measures would limit any potential cumulative impact. As a result, this aspect is not considered significant.

116. There is no other cumulative effect expected in respect of construction noise. As a result, this is considered **Not Significant**.

13.9. Mitigation

13.9.1 Operational Noise

117. Embedded mitigation measures have been adopted such as the layout being iteratively designed so as to achieve an acceptable noise impact on nearby receptors whilst maintaining as far as possible the generation capacity of the proposed Development (in addition to other design considerations).

118. Operational noise levels are predicted to comfortably meet the requirements of ETSU-R-97. As a result, no specific mitigation is prescribed here. However, it is entirely possible that noise from the proposed Development would be audible at receptor locations at times.

119. Operational noise would, in practice, be controlled via planning conditions which set out noise limits for the proposed Development.

13.9.2 Construction Noise

120. Noise during construction and decommissioning works would be controlled by generally restricting works to standard working hours and exclude Sundays, unless specifically agreed otherwise with A&BC and the appointed contractor undertaking the construction works. Embedded mitigation measures such as the provision of a Construction Environmental Management Plan (CEMP) (see **Appendix 3.1**) will ensure that noise and vibration levels are controlled in an appropriate manner.

121. BS 5228 states that the ‘attitude of the contractor’ is important in minimising the likelihood of complaints and therefore consultation with the local authorities would be required along with providing information to residents on intended activities.

122. The construction works on-site would be carried out in accordance with:

- relevant EU Directives and UK Statutory Instruments that limit noise emissions from a variety of construction plant;
- the guidance set out in PAN1/2011 and BS 5228: 2009;
- PAN50; and
- Section 61 of the Control of Pollution Act 1974 and Section 80 of the Environmental Protection Act.

123. There are no residential properties within 143 m of any road improvements and therefore construction noise is not a consideration.

124. A noise control plan would be produced that includes:

- procedures for ensuring compliance with statutory or other identified noise control limits;
- procedures for minimising noise from construction related traffic on the existing road network;

- procedures for ensuring that all works are carried out in accordance with the principle of "Best Practicable Means" as defined in the Control of Pollution Act 1974; and
- general induction training for site operatives, and specific training for staff having responsibility for particular aspects of controlling noise from the site.

125. In terms of the blasting for the proposed Development, unless otherwise agreed in consultation with A&BC, for example due to large separation distances, if blasting is to be employed at some of the borrow pits, the potential noise and vibration effects of blasting operations would be reduced according to the guidance set out in the relevant British Standards and PAN50 Annex D. The most appropriate mechanism is for a pre-blasting noise management programme to be prepared which would identify the most sensitive receptors that could be potentially affected by blasting noise. The programme would contain details of the proposed frequency of blasting, and proposed monitoring procedures. The operator would inform the nearest residents of the proposed times of blasting and of any deviation from this programme in advance of the operations. The programme would also contain contact details which would be provided to local residents should concerns arise regarding construction and blasting activities.

126. Effects during rock extraction from noise will be minimised by keeping the use of processing plant to a minimum. The blast pattern would be kept tight to maximise fragmentation, although some processing is likely to be required to produce aggregate of suitable grade for track construction. Blast design, including charge weights and delays, will be the responsibility of the contractor. Processing plant would be operated only for short periods of time, as necessary to provide the aggregate requirement for construction works.

127. The construction working hours for the proposed Development would be 7am to 7pm Monday to Friday and 7am to 4pm on weekends, though noisy activities on weekends would be restricted to reduce disturbance to nearby properties. It should be noted that out of necessity due to weather conditions and health and safety requirements, some generally quiet activities, for example, abnormal load deliveries (which are controlled by Police Scotland) and also the lifting of the turbine components, may occur outside the specified hours stated. The timing of the delivery of abnormal loads (i.e. wind turbine blades) will be agreed with the relevant authorities after detailed investigation.

13.10. Residual Effects

13.10.1 Operational Noise

128. No significant residual operational effects are predicted as operational noise levels meet the relevant derived noise limits without mitigation/curtailment applied to the turbines, although it is entirely possible that noise from the proposed Development would be just audible at receptor locations at times (see **Section 3.13** of this Chapter for further information). However, noise levels will meet planning guidelines in this regard.

129. The substation, ground mounted solar arrays, BESS and ancillary services proposed as part of the proposed Development have a limited noise output and would be located sufficiently far enough, with limited (or no) visibility, from neighbouring residential properties to result in no impacts that could be considered significant.

130. Operational noise would, in practice, be controlled via planning conditions which set out noise limits for the proposed Development.

13.10.2 Construction Noise

131. No significant residual construction and decommissioning effects are expected as construction noise levels will be below the adopted noise limit, although it is possible that noise from construction activities could be audible at receptor locations at times.

13.11. Summary and Statement of Significance

132. A noise assessment was carried out in order to determine whether the proposed Development meets typical planning requirements in respect of operational noise from wind turbines. The assessment takes in to account the methodologies set out within ETSU-R-97, The Assessment and Rating of Noise from Wind Farms (1996) and the Institute of Acoustic document, A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise.

133. Background/baseline noise measurements were undertaken at two locations to the south of the proposed Development as these were considered to be most sensitive to operational noise from the proposed turbines and suitably representative of other dwellings in the area.

134. The results of the operational noise assessment indicate that predicted levels comfortably meet the minimum requirements of ETSU-R-97 and therefore no specific mitigation is required. The noise impact is, therefore, determined to be not significant.

135. The substation, ground mounted solar arrays, BESS and ancillary services proposed as part of the proposed Development have a limited noise output and would be located sufficiently far enough, with limited (or no) visibility, from neighbouring residential properties. As a result, these aspects will not result in any significant impacts.

136. Construction and decommissioning noise levels at neighbouring dwellings are expected to meet typical requirements in this regard and no specific mitigation measures are considered to be required other than that deemed necessary under normal best practice.

137. On the basis of the embedded measures and proposed mitigation set out where necessary, there are no residual significant noise, cumulative noise or vibration effects predicted from the operation or construction of the proposed Development.

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