Vale of Leven Wind Farm Limited

Vale of Leven Wind Farm

Environmental Impact Assessment Report (Volume 1)

Chapter 11 – Noise and Vibration

663510 – 3 (00)

IEMA
Transforming the world to sustainability
- EIA -

RSK

OCTOBER 2023

CONTENTS

TABLES

FIGURES

11 NOISE AND VIBRATION

11.1 Introduction

11.1.1 RSK Acoustics have undertaken an assessment of the construction and operational noise levels resulting from the Vale of Leven Wind Farm (the Proposed Development), located in the Kilpatrick Hills, West Dunbartonshire on behalf of Vale of Leven Wind Farm Limited.

11.1.2 The Proposed Development consists of 10 wind turbines, each with a maximum blade tip height of 250 m, with access tracks, borrow pits, construction compounds, crane pads, Lidar unit, substation and Battery Energy Storage System (BESS) facilities within the substation area.

11.1.3 The Site is located just over 2 km east of Bonhill.

11.1.4 The closest third-party noise sensitive receptor (NSR), Highdykes Farm is located approximately 1.8 km to the nearest proposed turbine location T08.

11.1.5 Noise levels associated with the construction phase of the Proposed Development have been assessed against BS 5288-1:2009+A1:2014 'Code of practice for noise and vibration control on construction and open sites – Part 1: Noise' (BS 5228-1), as recommended by PAN1/2011 and accompanying Technical Advice Note. This consists of a haul road assessment of the access track (in accordance with BS 5228-1) along the Proposed Developments Site Access, as the main construction activities for The Site are scoped out at this stage due to the distance to NSRs.

11.1.6 An indicative assessment of blasting over pressure has been assessed from the proposed southwestern borrow pit (closest borrow pit to closest NSR at 2.5 km to Highdykes Farm). to appraise the potential impact using AS 2187.2-2006 'Explosives-Storage and use Part 2: Use of explosives' against a criteria discussed in BS 5288-1:2009+A1:2014 'Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration' (BS 5228-2), as this may be required for the Proposed Development.

11.1.7 The operational assessment has been assessed against ETSU-R-97 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97) and 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).

11.1.8 The Scottish Government's Online Renewables Planning Advice on Onshore wind turbines provides further advice on noise and confirms that the recommendations of 'The Assessment and Rating of Noise from Windfarms' (ETSU-R-97) "should be followed by applicants and consultees and used by planning authorities to assess and rate noise from wind energy developments"

11.1.9 Baseline noise measurements were undertaken at two residential properties in the extended vicinity of the Proposed Development and correlated with on-site wind speed measurements. West Dunbartonshire Council (WDC) were made aware of the monitoring locations and proposed survey methodology. From the baseline noise measurements, noise targets have been derived in accordance with ETSU-R-97 and GPG.

11.1.10 Predictions of the operational noise levels have been based on the candidate turbine being a Vestas 172 7.2MW. It should be noted that test results for this specific turbine are not yet available; therefore representative noise data has been adopted from a similar Vestas V136 turbine as outlined in the noise emission data sheets provided for the Vestas 172 wind turbine.

11.1.11 Cumulative assessment from other existing windfarms has not been considered due to large distances (approximately 12 km) from the Proposed Developments NSRs and other windfarms. As such it is anticipated that other windfarms are below 10 dBA from the Proposed Developments noise levels.

11.1.12 This chapter should be read in conjunction with **Technical Appendix 11.1** – Environmental Noise Assessment: Supplementary Information.

11.2 Scope and Methodology

11.2.1 The methodology adopted for this noise impact assessment is as follows:

- Review of relevant guidance and setting of suitable construction and operational phase noise criteria;
- Characterisation of the receiving noise environment;
- Prediction of noise effects due to the Proposed Development;
- Specification of mitigation measures, and;
- Evaluation of residual noise impacts and effects.

11.2.2 A noise assessment of the access track from the site access is considered. The entrance is proposed along Stirling Road/A813, opposite Aggreko Dumbarton. The site access road runs along Bellsmyre Avenue and Valeview Terrace at a nearest distance of approximately 250 metres. The assessment has been undertaken in accordance with BS 5228-1:2009+A1: 2014, calculation methodology F.2.5. These levels are compared against absolute noise targets for temporary construction activities which are considered to be appropriate in this regard.

11.2.3 The impact of air overpressure, caused by blasting has been assessed to the nearest NSR from the proposed southwestern borrow pit within the main turbine area. Predictions incorporate the calculation procedure within AS 2187.2 against criteria discussed in BS 6472-2:2008 'Guide to evaluation of human exposure to vibration in buildings Part 2: Blast-induced vibration' (BS 6472-2).

11.2.4 ETSU-R-97 and GPG is used for the assessment of the operation of the development. Computer noise modelling of a previous candidate turbine (Siemens Gamesa 6.6 170) for the Proposed Development during the scoping phase identified that zero NSRs were within the ETSU-R-97 35 dB $L_{A90,10min}$ noise contour. The project team decided that noise monitoring would still be sought to increase robustness of the noise assessment.

11.3 Assessments Scoped out

11.3.1 Due to the large distances between The Site and NSRs (over 1 km), a construction plant noise assessment has been scoped out.

11.3.2 Operational noise from the Proposed Development excluding turbines, such as transformers, BESS, and other ancillary equipment, has been scoped out due to the distance between the indicative substation to the nearest NSR, Highdykes Farm, of approximately 1.6 km, as shown in **Figure.1**.

11.3.3 Vibration associated with the construction and operation of the development is also scoped out , as it is considered that distances over 20 m from sources of vibration may not be adversely affected, The nearest receptor to The Proposed Development is greater than 100 m away.

11.3.4 Cumulative noise assessment from surrounding wind turbines has been scoped out, as it is considered that surrounding turbines are at a significant distance to surrounding NSRs.

11.4 Consultation Undertaken

11.4.1 A scoping report which included details of relevant planning policy and guidance for both operation and construction phases was submitted in April 2022 to West Dunbartonshire Council (WDC). The scoping report discussed the indicative process to assess the operational and construction noise levels from the Proposed Development.

11.4.2 Correspondence letters were sent to residents of properties where monitoring was proposed, as well as a letter to WDC explaining the proposed noise monitoring process. Noise monitoring was successfully installed following the letters being issued at two of the three proposed monitoring locations (Highdykes Farm and Gallangad Lodge), details of the noise monitoring is presented in Chapter 11 Annex A.

11.4.3 A consultation meeting with WDC was held in April 2023 to discuss the scope and methodology with regards to noise for the Proposed Development.

11.4.4 A summary of the consultations completed is presented below in **Table 11.1**.

Table 11.1: Summary of Consultations

Development Stage	Date	Consultation Type	Consultees	Response
Scoping	14 April 2022	Scoping Report	WDC	No response regarding noise
Baseline Noise Monitoring	18 November 2022	Noise monitoring and assessment approach letter	WDC	No response
	18 November 2022	Proposed noise monitoring installation letter	NSRs	Accepted noise monitoring installation at 2 properties
Environmental Impact Assessment Reporting	20 April 2023	Virtual meeting	WDC	Discussion and indicative agreement on assessment approach

11.5 Statutory and Planning Context

Planning Policy

11.5.1 Planning Advice Note 1/2011: Planning and Noise (PAN1/2011) presents general advice on preventing and limiting the adverse effects of noise without prejudicing economic development for Scotland.

11.5.2 PAN1/2011 provides guidance on how the planning system helps to prevent and limit the adverse effects of noise. This document promotes the principles of good acoustic design and a sensitive approach to the location of new development.

11.5.3 Section 29 discuss noise from wind turbines, stating:

"There are two sources of noise from wind turbines - the mechanical noise from the turbines and the aerodynamic noise from the blades. Mechanical noise is related to engineering design. Aerodynamic noise varies with rotor design and wind speed, and is generally greatest at low speeds. Good acoustical design and siting of turbines is essential to minimise the potential to generate noise. Web based planning advice on renewable technologies for Onshore wind turbines provides advice on 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97) published by the former Department of Trade and Industry [DTI] and the findings of the Salford University report into Aerodynamic Modulation of Wind Turbine Noise."

11.5.4 Further documentation from The Scottish Government is provided within the online 'Onshore wind turbines; planning advice' which discusses a variety of documents on the impacts of noise from wind farms. It confirms that ETSU-R-97 is still a suitable form of assessment for operational noise from wind farms.

Construction Noise

11.5.5 PAN1/2011 and accompanying Technical Advice Note make reference in particular to BS 5228-1 for construction noise. It is usually accepted that construction and decommissioning activities are of a temporary nature when assessing their impact. The potential effects due to noise during construction and decommissioning will be undertaken in accordance with the BS 5228-1:2009+A1: 2019. Where predictions of construction noise will reference typical activity emission levels and likely variations in noise levels at surrounding receiver locations.

11.5.6 Annex E of BS 5228-1:2009+A1: 2019 provides guidance on how to assess the significance of construction noise on residential and NSRs, with a number of assessment methods to determine the significance of construction related impacts.

11.5.7 Section E.3.2 details the 'ABC Method' of determining the potential significance of noise effects based upon noise change. This method requires the quantification of the existing baseline climate and the assessment of construction noise, in isolation, against the existing ambient levels.

11.5.8 In order to determine the significance of potential noise effect at dwellings, firstly the baseline climate is quantified for the appropriate assessment period (daytime, evening/weekends or night) and rounded to the nearest 5 dB. This is then compared to the measured or predicted noise levels from The Proposed Development. If The Site noise level exceeds the appropriate category value, as listed in **Table 11.2** below, then a potential significance is indicated.

Table 11.2: Example threshold of significant effect of construction noise at dwellings

Assessment category and threshold value period (L_{Aeq})	Threshold value in decibels		
	Category A [A]	Category B [B]	Category C [C]
Night-time (23.00 – 07.00)	45	50	55
Evening and weekends [D]	55	60	65
Daytime (07.00 – 19.00) and Sat (07.00 – 13.00)	65	70	75
NOTE 1 A potential significant effect is indicated if the $L_{Aeq,T}$ noise level arising from the site exceeds the threshold level for the category appropriate to the ambient noise level. NOTE 2 If the ambient noise level exceeds the Category C threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a potential significant effect is indicated if the total $L_{Aeq,T}$ noise level for the period increases by more than 3 dB due to site noise. NOTE 3 Applied to residential receptors only.			
[A] Category A: Threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values [B] Category B: Threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as the category A values [C] Category C: Threshold values to use when the ambient noise levels (when rounded to the nearest 5 dB) are higher than category A values. [D] 19.00 – 23.00 weekdays, 13.00-22.00 Saturdays and 07.00 – 23.00 Sundays.			

11.5.9 Baseline noise levels were not captured at the NSR closest to the Site Access route due to their extended distance from the route of approximately 250 metres, therefore a conservative assessment to approach has been taken to designate them within Category A thresholds.

11.5.10 It is considered that if the construction noise level, all noise related to the construction phase, exceeds the appropriate category value (e.g. 65 dB $L_{Aeq,T}$ during daytime periods) then a significant effect is deemed to have occurred.

Blasting

11.5.11 Blasting can generate airborne pressure waves, called air overpressure. These can be generated within the human audibility spectrum (around 20 Hz to 20 kHz), and below the audibility spectrum, infra sound (below 20 Hz), which can sometimes be felt.

11.5.12 Planning Advice Note 50 (PAN 50) 'Controlling the Environmental effects of Surface Mineral Workings' provides guidance for this assessment approach, which discusses:

"34 - Blasting at surface mineral working gives rise to a number of effects:

Vibration; the levels of vibration generated by mineral workings are well below those required to cause structural damage to properties. However, vibration transmitted through the ground and pressure waves through the air ('overpressure') shake buildings and people and may cause nuisance. The effects of the two factors are difficult for even an expert to distinguish without instrumentation. However, the pressure wave may arrive after the ground vibration by up to 2 seconds over a distance of 1 km. The perception of both factors is likely to be stronger inside a building than outside……..."

"38 – "……audible noise, because it is part of the pressure wave, occurs at the same time as overpressure. It may be augmented by the rattling of windows etc., caused by the overpressure,…"

11.5.13 Blasting Overpressure is indicatively assessed to the nearest NSR from the proposed southwestern borrow pit, these calculations have been assessed in accordance with AS 2187.2-2006.

11.5.14 BS 6472-2:2008 discusses blasting criteria stating:

"Windows are generally the weakest parts of a structure exposed to air overpressure. Research by the United States Bureau of Mines has shown that a poorly mounted window that is pre-stressed can crack at around 150 dB(lin), with most windows cracking at around 170 dB(lin). Structural damage would not be expected at air overpressure levels below 180 dB(lin).

The air overpressure levels measured at properties near quarries in the United Kingdom are generally around 120 dB(lin), which is 30 dB(lin) below, or only 3% of, the limit for cracking pre-stressed poorly mounted windows."

11.5.15 A target of 120 dB(lin) from blasting is used as the criteria for the assessment as this is considered to be a suitable criterion as discussed within BS6472-2:2008.

Operational Noise

11.5.16 ETSU-R-97 recommends that noise targets for wind turbines should be set relative to existing external background noise levels across a variety of windspeeds, from the cut-in speed (the lowest speed the turbine operates) to 12 m/s (referenced to 10 metres above ground) at nearest NSRs. This assessment considers that noise levels from 9 m/s higher speeds contribute the same impact of operational noise, as the same broadband noise level from the wind turbines is given at these speeds, shown in **Table 11.8**.

11.5.17 Where background noise levels are low, it is considered that a margin above the background noise level would be unduly restrictive on developments and not necessary. In these instances, absolute noise targets are recommended.

11.5.18 Noise targets (free-field except for ground reflections) are dependent on the day and time within a week, due to the expected location of NSRs being outside or inside their dwellings.

11.5.19 Daytime periods used for operational noise assessments of wind farms, referred to as 'quiet daytime periods' within ETSU-R-97 are defined as:

- All evenings from 6pm to 11pm (18:00 – 23:00),
- Saturday afternoon from 1pm to 6pm (13:00 – 18:00).
- Sunday 7am to 6pm (07:00 – 18:00).

11.5.20 During these daytime periods noise from wind farms should be targeted to either 35-40 dB $L_{A90,10min}$ (dependant on the number of dwellings, wind farm kWh generated, and duration and level of exposure) or 5 dB above the background noise level, whichever is the highest.

11.5.21 Night-time periods used for operational noise assessments of wind farms within ETSU--R--97 are defined as between 11pm to 7am (23:00 – 07:00) Monday to Sunday. During these night-time periods noise from wind farms should be targeted to either

43 dB $L_{A90,10min}$ or 5 dB above the background noise level, whichever is the highest. The night-time noise target is higher due to the expectation that occupiers at NSRs are inside their dwellings and accounts for the 35 dB(A) sleep disturbance criteria within Planning Policy Guidance Note 24 (since withdrawn and superseded by BS 8233: 2014 and/or WHO, 1999, with an allowance of 15 dB(A) for attenuation through an open window and a subtraction of 2 dB to account for the use of $L_{A90,T}$ rather than $L_{Aeq,T}$ from $L_{A90,T}$ discussed in ETSU-R-97 and $L_{Aeq,T}$ discussed in PPG 24 (and BS 8233: 2014 and/or WHO, 1999).

11.5.22 Where the occupier of a property has financial involvement (which is not the situation in this assessment) in the wind farm, the daytime and night-time lower noise targets can be increased to 45 dB $L_{A90,10min}$ and consideration to increasing the permissible margin above background should also be considered.

11.5.23 Noise targets for daytime and night-time are derived from the background noise levels measured during the baseline noise measurements within the corresponding times discussed above, shown in **Table 11.5** and **Table 11.6**. The baseline noise measurement background levels are plotted against simultaneously measured wind speed at the development (and filtered for unsuitable periods such as rainfall) until sufficient data is measured to draw a suitable line of best fit from the data. This background noise line of best fit can then be used to derive noise targets across different wind speeds.

11.5.24 The daytime and night-time targets should relate to the cumulative effect of existing and proposed wind farms. This means that existing wind farms should not be considered as part of the prevailing background noise levels for proposed wind farms and targets for new wind farms should be compared with cumulative predictions with the existing wind farms, no cumulative effect from other wind farms is considered for this assessment as there are no wind farms within notable proximity that affect the assessment.

11.5.25 Additionally, where predicted noise levels from wind farms are less than 35 dB $L_{A90,10min}$ at NSRs, noise surveys are not considered necessary (dependent on project requirements).

11.5.26 It is important to note that ETSU-R-97 refers to $L_{A90,10min}$ as both the background noise level and wind farm noise. This is different to other noise assessments which may use forms of the L_{Aeq} for noise from developments rather than the L_{A90}. The use of $L_{A90,10min}$ for wind farm noise allows for reliable measurements to be made without corruption from relatively loud, transitory noise events from other sources. It is considered that the $L_{A90,10min}$ is likely to be 1.5 – 2.5 dB less than the L_{Aeq} measured over the same period. The L_{Aeq} is the equivalent continuous A-weighted sound pressure level occurring over the measurement period, and could be described as the average noise level. The L_{A90} is the level exceeded for 90% of the measurement, where noise sources emit a constant sound level the L_{Aeq} and L_{A90} would be comparable.

11.5.27 GPG expands on the application of ETSU-R-97, which clarifies and provides additional guidance for ETSU-R-97.

11.5.28 British Standard 8233:2014 ‘Guidance on Sound Insulation and Noise Reduction for Buildings’ also discuss noise from wind farms within Section 6.7 and states that ETSU-R-97 and GPG should be used for the assessment of wind farms.

11.5.29 Additional Statutory and Planning context is presented within **Technical Appendix 11.1** and the detailed context is contained in the Planning and Sustainability Statement which accompanies this application.

11.6 Existing Environment

11.6.1 The location of the Proposed Development is located just over 2 km east of Bonhill . The sound environment in the surrounding area was observed during attendance and is generally characterised by natural sources, such as birdsong, wind disturbed vegetation, agricultural vehicle movements, and occasional road traffic along Auchincarroch Road.

11.6.2 There are no other wind farms (either proposed or built) within the vicinity of the Proposed Development. The nearest wind turbines is considered to be at Priestside farm, located approximately 12 km to the southwest of the Proposed Development. Due to the large distance to the turbines, cumulative assessment has been scoped out.

11.6.3 During the scoping assessment, zero NSRs were within the 35 dB $L_{A90,10min}$ noise contour from the Proposed Development. It was decided by the project team to obtain baseline noise measurements from surrounding noise-sensitive NSRs.

11.6.4 The selection of monitoring locations was supplemented by reviewing aerial images of the study area and other online sources of information (e.g. Google Earth).

11.6.5 Initially, three noise monitors were installed at surrounding dwellings. One meter was removed following a request by the occupants and the data collected from this meter has not been used within this assessment. **Table 11.3** and **Table 11.4** present the locations of the completed baseline noise measurement locations between 21 December 2022 and 21 February 2023 to the requirements of ETSU-R-97, with additional information in Chapter 11 Annex A.

Table 11.3: Noise Monitoring Locations

Dwelling	Easting	Northing	Approximate Distance to Closest Turbine (m)	Closest Turbine	Equipment used
Gallangad Lodge	244135	683122	2,400	2	01 dB Fusion 14155
Highdykes Farm	241031	678690	1,800	8	01 dB Fusion 14157, weather gauge installed at this location

Measurement Locations

Gallangad Lodge

11.6.6 Gallangad Lodge is located to the north of the Proposed Development. The noise monitor was installed along the western side of the garden; considered to be under free-field conditions. Noise sources observed during the installation, maintenance, and collection included birdsong, wind disturbed vegetation, and occasional road traffic along Auchincarroch Road**.**

Highdykes Farm

11.6.7 Highdykes Farm is located to the west of the Proposed Development. The noise monitor was installed along the eastern side of the property, and considered to be under free-field conditions. Noise sources observed during the installation, maintenance, and collection included birdsong, wind disturbed vegetation, and in lulls of closer sound sources distant road traffic to the south and west.

Financially Involved Receptors

11.6.8 Merkins Farm is located to the north of the development and around 400 m closer to the development than Gallangad Lodge. The assessment of Gallangad Lodge is considered to be suitably representative for Merkins Farm as it is considered that impacts to Gallangad Lodge are similar to those that would be to Merkins Farm.

Instrumentation

11.6.9 The baseline noise survey was carried out using 01dB model Fusion 40CD sound level metres, fitted with 1/2" prepolarized condenser microphones that comply with Class 1 standard in IEC 61672-1:2002. The microphones were mounted on tripods at heights approximately 1.2m – 1.5m above the ground, located and fitted with specialist windshields as per the design recommendations within ETSU W/13/00386/REP, 'Noise Measurements in Windy Conditions'. Onsite calibration of each metre was undertaken before deployment, maintenance visits approximately every 2 weeks, and after collection. Calibration drift was less than 0.5 dB for each meter; this is considered within normal tolerances.

11.6.10 Onsite wind data was gathered via a LiDAR device installed within the Proposed Development, which obtained measurements of weather data at the hub height of the proposed turbine.

11.6.11 Rainfall data was collected from the installed weather gauge, which logged rainfall in 10 minutes intervals time synchronised to a GPS signal. This allows for any corresponding noise data that may have been affected by rainfall to be removed from the analysis.

Measurement Procedure

11.6.12 The sound level metres were programmed to collect a range of data metric's, including the L_{A90} and L_{Aeq}, and were logged in 10 minute intervals.

11.6.13 Wind shear has been addressed by relating background noise measurements to 164 metre height wind speed (i.e. the approximate hub height of the candidate turbine model) with the following equation:

$$U = U_{ref}\left[\frac{H}{H_{ref}}\right]^{m}$$

where U is the calculated wind speed, U_{ref} is the measured wind speed, H is the height of the wind speed to be calculated, H_{ref} is the height of the measured wind taken, and m is the shear exponent:

$$m = \frac{\log\left(\frac{u}{u_{ref}}\right)}{\log\left(\frac{H}{H_{ref}}\right)}$$

11.6.14 The derived hub height wind speed has been corrected to 'standardised' 10m as detailed within the GPG:

$$U_1 = U_2\frac{ln(10/z)}{ln(H/z)}$$

11.6.15 Where U_1 is the 'standardised' wind speed at 10 metres, U_2 is the measured wind speed, H is the hub height and z is the reference ground roughness length (=0.05 m). This method ensures that the comparisons of predicted turbine noise level, background level and the corresponding noise targets are made on a like-for-like basis.

Survey Results

11.6.16 The noise, wind and rain data collected have been analysed in accordance with the requirements of ETSU-R-97, as refined by the GPG.

11.6.17 Background noise levels during day and night-time hours have been derived by plotting the measured L_{A90} against the standardised 10 metre height wind speeds. These are shown in **Technical Appendix 11.1**. Day and night-time periods have been defined as per ETSU-R-97. All data has been referenced to local time.

11.6.18 Any 10 minute periods where rainfall was recorded is shown by red circles and has been removed from the background noise levels across all measurement locations.

11.6.19 Second order lines of best fit have been calculated through the respective day and night-time background noise data to generate the prevailing background noise levels across a range of wind speeds, shown in **Table 11.4**.

Table 11.4: Summary of Baseline Background Sound Levels, dB

Dwelling	Period	Derived $L_{A90,10min}$ baseline sound levels (dB) (standardised 10 metre height) - wind speed (m/s)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Gallangad Lodge	Day	32.1	31.1	30.6	30.5	30.9	31.7	33.0	34.7	36.9	39.6	42.7	46.2	50.3	54.7	59.7
	Night	27.8	27.8	28.1	28.8	29.7	31.0	32.7	34.6	36.8	39.4	42.3	45.5	49.1	52.9	57.1
Highdykes Farm	Day	27.6	27.9	28.5	29.2	30.0	31.0	32.2	33.6	35.1	36.8	38.7	40.7	42.9	45.2	47.8
	Night	27.3	26.4	25.9	25.8	26.1	26.8	27.8	29.3	31.1	33.4	36.0	39.0	42.4	46.2	50.3

11.6.20 Noise targets have been derived from the baseline noise measurements for daytime and night-time periods in accordance with GPG, for wind speeds up to 15 metres per second, and are summarised in **Table 11.5** and **Table 11.6** below. Full details of the baseline noise measurements and derivation of these noise targets are detailed in **Technical Appendix 11.1**.

Table 11.5: Derived daytime, $L_{A90,10min}$ dB noise targets from baseline noise data

NSR	Derived daytime, $L_{A90,10min}$ dB noise targets (standardised 10 metre) - wind speed (m/s)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Gallangad Lodge	36.1	35.6	35.5	35.9	36.7	38.0	39.7	41.9	44.6	47.7	51.2	55.3	59.7	64.7	70.1
Highdykes Farm	35.0	35.0	35.0	35.0	36.0	37.2	38.6	40.1	41.8	43.7	45.7	47.9	50.2	52.8	55.5

Table 11.6: Derived night-time, $L_{A90,10min}$ dB noise targets from baseline noise data

NSR	Derived night-time, $L_{A90,10min}$ dB noise targets (standardised 10 metre) - wind speed (m/s)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Gallangad Lodge	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.4	47.3	50.5	54.1	57.9	62.1	66.6
Highdykes Farm	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.0	47.4	51.2	55.3	59.9

11.6.21 Based on the relevant guidelines and baseline noise levels, it is considered that a significant adverse effect would only occur should turbine noise levels exceed the values within **Table 11.5** and **Table 11.6**.

11.7 Predicted Impacts

Construction Phase

Turbine Area

11.7.1 The turbine area is approximately 1.8 km to the nearest NSR, Highdykes Farm, shown in **Figure 1.1**. Due to this large distance, construction activities within the Proposed Development are scoped out.

HGV Movements along the Access Road

11.7.2 The site access route for construction traffic is proposed along Stirling Road/A813 opposite Aggreko Dumbarton, with the access track running along Bellsmyre Avenue and Valeview Terrace at around 250 metres distance.

11.7.3 Due to the short duration of the construction of the access track, an assessment of this section of works is not considered. Noise calculations of the construction traffic along the access track has been completed to assess the possible impact from this works on the NSRs at Bellmyre Avenue. Calculation F.6 from BS 5228-1 was used for this assessment, using the data shown in **Table 11.7**:

$$L_{\mathrm{Aeq,T}} = L_{WA} - 33 + 10\log_{10} Q - 10\log_{10} V - 10\log_{10} d$$

11.7.4 Where L_{WA} is the sound power of the plant, in dB, Q is the number of vehicles per hour, V is the average vehicle speed, in km/h, and d is the distance of receiving position from the centre of the haul road, in metre.

11.7.5 This assesses the worst-case estimated traffic along the access track, considered consistent with the Traffic and Transport chapter, of 116 movements per day assumed on a Saturday weekend (6 hour period) resulting on just over 19 movements per hour using reference data of a 90T Dump truck, c.9.16 from BS 5228-1.

Table 11.7: Mobile Plant along Access track Noise Emission Values

Noise level at NSR, $L_{Aeq,1hr}$*	Criteria, $L_{Aeq,T}$	Sound Power of vehicles, L_{WA} dB	Number of vehicles per hour, Q	Speed of vehicles, km/h	Distance to NSR (metres)
33	65	91	19	24	250
** assumes worst case assumption of direct line of sight between source and receiver, and 180º angle of view*					

11.7.6 The predicted noise emissions at the NSR from construction activity along the access road as is within the daytime construction noise limit criteria of 65 dB $L_{Aeq,T}$ presented in the category A criteria of **Table 11.2**.

Blasting

11.7.7 There is scope for blasting during the construction stage of the Proposed Development within the borrow pits. It is difficult to predict air over pressure caused by blasting,

however, the worst case is considered below. The nearest blasting receptor for the borrow pits within the Proposed Development is Highdykes Farm, situated approximately 2,500 metres away.

11.7.8 Blasting is best controlled using good practice, discussed in AS2187.2 2006, during the setting and detonation of charges, particularly by limiting the maximum instantaneous charge weight. Using the calculation formula within AS2187.2 2006:

$$P = K_a \left(\frac{r}{Q^{1/3}}\right)^a$$

where P is the calculated pressure in kPa, Q is the mass of the explosive charge in kg, r is the distance from the explosive charge, K_a is the site constant and a is the site exponent.

11.7.9 Assuming a confined surface charges with a site constant K_a of 100, a site exponent of -1.45, and a charge mass/weight of 10kg (excluding meteorological effects); results indicate that a resulting overpressure level of 3 PA (44 dB (lin)) is likely at Highdykes Farm. It is therefore proposed that this borrow pit will not be excavated by using blasting. It is anticipated that blasting from the borrow pits within the Proposed Development area would not cause any significant adverse impacts.

11.7.10 It is considered that the decommissioning phase of the development would result in similar or less noise than the construction phase.

11.7.11 Based on the assessment of construction and decommissioning impacts, it is considered that the effects on the access track traffic and blasting, would be negligible and not significant.

Operational Phase

11.7.12 Using the Vestas EnVentus 172-7.2MW candidate turbine, the loudest turbine selected during the design, with no serrated trailing edges, sound power data, a hub height of 164 metres, and the layout in **Figure 2.5**, **Chapter 2: Proposed Development,** a noise model was created to assess to potential impact of the turbines. Using SoundPlan v8.2, which utilises ISO 9613: Acoustics – Attenuation of sound outdoors, Part 2: General method of calculation, 1996. SoundPlan calculates noise levels predominantly taking into account a range of factors including:

- The magnitude of the noise source in terms of Sound Power Level (dB L_{wA});
- The distance between the source (turbines) and receiver (NSR);
- The presence of obstacles such as screens, barriers, or buildings in the propagation path;
- The hardness of the ground between the source and receiver;
- Attenuation due to atmospheric absorption; and
- Meteorological effects such as wind gradient, temperature gradient and humidity.

11.7.13 The noise assessment is presented in terms of $L_{A90,10mins}$. The provided turbine noise data, in terms of L_{wA} has a margin of error of 2 dB, which is the same value to subtract to get L_{A90} levels from:

"The Noise Working Group is agreed that the $L_{A90(10\ minutes)}$ descriptor should be used for both the background noise and the wind farm noise and that when setting limits, it should

be borne in mind that the $L_{A90(10\ minutes)}$ from the wind farm is likely to be 1.5 – 2.5 dB(A) less than the L_{Aeq} measured over the same period."

11.7.14 Therefore, the noise data of the candidate turbine has been used for the assessment without correction, barring standardisation to 10 metres. **Table 11.8** shows the octave band data used in the noise model.

Table 11.8: Wind Turbine Sound power level referenced to standardised 10 m Hub Height

Frequency (Hz)	Standardised 10 metre wind turbine sound power level (L_{WA} dB) - wind speed (m/s)												
	3	4	5	6	7	8	9	10	11	12	13	14	15
8	29.0	28.1	28.1	28.5	29.3	29.3	32.8	36.4	36.4	39.9	41.7	42.4	43.1
16	48.6	47.3	44.6	45.0	45.4	50.5	55.6	55.6	58.9	60.3	60.6	61.1	61.7
31.5	65.9	61.5	59.2	58.9	64.8	71.1	72.5	75.9	77.2	77.2	77.5	77.8	78.1
63	90.8	82.4	86.7	90.6	97.6	102.7	104.1	104.0	104.0	104.0	104.0	104.0	104.1
125	88.0	86.7	88.5	91.5	95.0	98.1	99.3	99.3	99.4	99.5	99.5	99.4	99.3
250	65.9	61.5	59.2	58.9	64.8	71.1	72.5	75.9	77.2	77.2	77.5	77.8	78.1
500	90.8	82.4	86.7	90.6	97.6	102.7	104.1	104.0	104.0	104.0	104.0	104.0	104.1
1000	88.0	86.7	88.5	91.5	95.0	98.1	99.3	99.3	99.4	99.5	99.5	99.4	99.3
2000	65.9	61.5	59.2	58.9	64.8	71.1	72.5	75.9	77.2	77.2	77.5	77.8	78.1
4000	90.8	82.4	86.7	90.6	97.6	102.7	104.1	104.0	104.0	104.0	104.0	104.0	104.1
8000	88.0	86.7	88.5	91.5	95.0	98.1	99.3	99.3	99.4	99.5	99.5	99.4	99.3
A-weighted Broadband Level	97.8	93.1	95.4	100.3	104.8	108.6	110.1	110.1	110.1	110.1	110.1	110.1	110.1

11.7.15 Sound power levels (in **Table 11.8**) were used within the noise modelling software (SoundPlan v8.2), using ISO 9163. The propagation model described in Part 2 of this standard provides for the prediction of sound pressure levels based on either short-term downwind (i.e. worst case) conditions or long term overall averages.

11.7.16 For the assessment of the Proposed Development, only the worst-case downwind condition has been considered - wind blowing from the proposed turbines to NSRs.

11.7.17 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:

$$\boldsymbol{Octave\ Band\ Sound\ Level = L_w + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc}}$$

L_w is the sound power of the noise source, discussed above

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

A_{geo} is the geometrical divergence accounting for spherical spreading in the free-field from a point sound source, resulting in an attenuation depending on distance according to:

$A_{geo} = 20.\log_{10}(d) + 11,\ d = distance\ from\ noise\ source\ to\ receptor$

A_{atm} is the attenuation from atmospheric absorption, where the sound energy is converted to heat. This is dependent on temperature, relative humidity of the air, and frequency of sound. Modelling assumed a temperature of 10 ˚C and a relative humidity of 70%.

A_{gr} is the ground effect, which accounts for sound reflected by the ground along the sounds propagation path, taken as G =0.5.

A_{bar} is the influence of barrier attenuation between the source and NSRs. GPG discusses that this should be targeted to no higher than 2 dB, and only if there is no direct line of sight between the highest point of the turbine rotor and NSRs.

A_{misc} consists of miscellaneous other effects, such as propagation through foliage, industrial sites, and built-up regions of houses.

11.7.18 Octave band sound levels are then summed together to give the overall A-weighted predicted level.

11.7.19 There is also the effect of concave ground profiles where NSRs are located on the opposite side of a valley, which results in higher noise levels due to the reduced ground effect and/or focussing effect of the ground shape. The GPG suggest a simplified approach under paragraph 4.3.9 where an additional 3 dB or 1.5 dB if G=0 should be applied to NSRs under these conditions. Site topography for the Proposed Development indicates that no concave ground profiles exist at NSRs; corrections have therefore not been applied.

11.7.20 Additionally, NSRs have been specified to a relative height above ground of 4 m and assessed as all turbines running simultaneously, which is considered to be in compliance with GPG.

11.7.21 **Table 11.9** shows the predicted noise levels at NSRs from the Proposed Development. Predictions are shown as $L_{A90,10min}$, and assume no audible tones.

Table 11.9: Predicted operational nose levels, $L_{A90,10min}$ dB

NSR	Predicted Operational Noise Levels, $L_{A90,10min}$ dB (standardised 10 metres) - wind speed (m/s)												
	3	4	5	6	7	8	9	10	11	12	13	14	15
Gallangad Lodge	21.4	15.0	17.2	22.7	28.0	32.4	34.1	34.1	34.1	34.1	34.1	34.1	34.1
Highdykes Farm	24.4	18.2	20.4	25.9	31.1	35.4	37.0	37.0	37.0	37.0	37.0	37.0	37.0

11.7.22 **Table 11.10** and **Table 11.11** present the predicted levels against the adopted noise criteria.

Table 11.10: Predicted operational noise level at Gallangad Lodge compared to noise targets, $L_{A90,10min}$ dB

Level	Assessment of Operational Noise Levels, $L_{A90,10min}$ dB (standardised 10 metres) - wind speed (m/s)												
	3	4	5	6	7	8	9	10	11	12	13	14	15
Predicted operational noise level ($L_{A90,10min}$ dB)	21.4	15.0	17.2	22.7	28.0	32.4	34.1	34.1	34.1	34.1	34.1	34.1	34.1
Daytime Criteria ($L_{A90,10min}$ dB)	35.5	35.9	36.7	38.0	39.7	41.9	44.6	47.7	51.2	55.3	59.7	64.7	70.1
Daytime Excess	-14.1	-20.9	-19.5	-15.3	-11.7	-9.5	-10.5	-13.6	-17.1	-21.2	-25.6	-30.6	-36.0
Night-time Criteria ($L_{A90,10min}$ dB)	43.0	43.0	43.0	43.0	43.0	43.0	44.4	47.3	50.5	54.1	57.9	62.1	66.6
Night-time Excess	-21.6	-28.0	-25.8	-20.3	-15.0	-10.6	-10.3	-13.2	-16.4	-20.0	-23.8	-28.0	-32.5

Table 11.11: Predicted operational noise level at Highdykes Farm compared to night-time noise target, $L_{A90,10min}$ dB

Level	Assessment of Operational Noise Levels, $L_{A90,10min}$ dB (standardised 10 metres) - wind speed (m/s)												
	3	4	5	6	7	8	9	10	11	12	13	14	15
Predicted operational noise level ($L_{A90,10min}$ dB)	24.4	18.2	20.4	25.9	31.1	35.4	37.0	37.0	37.0	37.0	37.0	37.0	37.0
Daytime Criteria ($L_{A90,10min}$ dB)	35.0	35.0	36.0	37.2	38.6	40.1	41.8	43.7	45.7	47.9	50.2	52.8	55.5
Daytime Excess	-10.6	-16.8	-15.6	-11.3	-7.5	-4.7	-4.8	-6.7	-8.7	-10.9	-13.2	-15.8	-18.5
Night-time Criteria ($L_{A90,10min}$ dB)	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.0	47.4	51.2	55.3	59.9
Night-time Excess	-18.6	-24.8	-22.6	-17.1	-11.9	-7.6	-6.0	-6.0	-7.0	-10.4	-14.2	-18.3	-22.9

11.7.23 The results presented in **Table 11.10** and **Table 11.11** show that the predicted operational noise levels of the candidate turbine from the Proposed Development are below the adopted criteria during day and night periods. This indicates that the effects of the Proposed Development on the nearest sensitive receptors would be negligible and not significant.

11.7.24 The Proposed Development includes a substation with BESS installed on the adjacent site (shown in **Figure 2.5**). The main noise sources from these types of equipment are the transformers, inverters, and cooling systems. The substation and BESS are proposed within the south-eastern area of the Site, approximately 1.8 km to the nearest NSR (Highdykes Farm). Due to the distance between the proposed substation and NSR, it is anticipated the operational impact from these aspects would be negligible and not significant as operational noise from these aspects is anticipated to be inaudible.

11.8 Proposed Mitigation Measures

11.8.1 An outline Construction Environmental Management Plan (CEMP) will be secured through a planning condition. The outline CEMP includes measures to reduce potential effects during the construction and decommissioning phases, Best Practical Means BPM discussed within BS 5228-1 and 522802 would be implemented, such as proposed mitigation including:

- Contractor shall aim to be a proactive and considerate neighbour, for example, potentially affected residents shall be approached in advance of any potential disturbance and kept informed of works progress, with a noise complaint handling procedure and responded to quickly,
- Using normal working hours of Monday to Friday 07:00 – 19:00, Saturday 07:00 - 13:00, and no work during night-time hours/ Sundays/ Bank holidays where noise will be audible at the site boundary,
- Sunday working only undertaken in emergencies or with prior approval from the local authority,
- Noisy plant not used simultaneously and/or close together to avoid cumulative noise levels where possible,
- Turning generators off overnight, or measures implemented to minimise noise levels to nearest dwellings,

11.8.2 The effects of blasting will be reduced, for example:

- Blasting taken place in accordance with a Borrow Pit Management Plan (see TA 8.4) agreed with the planning authority. For example, controlling the hours of blasting and other proposed mitigation measures.
- There will be no excavation by blasting of the southwestern borrow pit

11.8.3 Based on the assessment within this chapter, specific mitigation would not be required during the operational phase of works.

11.9 Summary of Residual Effects

11.9.1 A noise assessment has been undertaken for the construction, decommissioning and operational stages of the Proposed Development .

11.9.2 The construction and decommissioning stages are predicted against derived criteria within BS 5228-1:2009+A1: 2014. The assessment of construction traffic along the access track and impact of blasting in the borrow pits, indicates levels that are below the threshold identified in the adopted criteria (see **Table 11.2**above). The impacts are found to be negligible and **not significant**.

11.9.3 Baseline noise measurements and criteria have been derived in accordance with ETSU-R-97 and GPG to assess the noise emissions for the operational stage of the development. Noise modelling of the Proposed Development including the substation and BESS predicts a negligible impact at NSRs; the effect of the proposals are therefore negligible and **not significant**.

11.9.4 Summary of the predicted impacts is shown in **Table 11.12**.

Table 11.12: Evaluation of Effects Summary

Proposed Development Stage	Evaluation
Construction	Not significant negligible temporary
Operation	Not significant negligible long term
Decommissioning	Not significant negligible temporary

11.10 References

British Standards Institute (2009 + 2014). BS 5228-1 + A1, Code of Practice for Noise and Vibration Control on Construction and Open Sites - Noise. BSI

Australian Business License and Information Service (2006). AS 2178.2, Explosives – Storage and Use – Use of Explosives. ABLIS

British Standards Institute (2009 + 2014). BS 5228-2 + A1, Code of Practice for Noise and Vibration Control on Construction and Open Sites - vibration. BSI

Department of Trade and Industry (1996). ETSU-R-97, The Assessment and Rating of Noise from Wind Farms. ETSU/DTI. Available at:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/49869/ETSU_Full_copy__Searchable_.pdf

Institute of Acoustics (May 2013). A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise. IOA. Available at: https://www.ioa.org.uk/publications/wind-turbine-noise

British Standards Institute (2008). BS 6472-2, Guide to evaluation of human exposure to vibration in buildings – Blast-induced vibration BSI

The Scottish Government (2011). Planning Advice Note 1/2011: planning and noise. [online] Available at: https://www.gov.scot/publications/planning-advice-note-1-2011-planning-noise/

The Scottish Government (2014). Onshore wind turbines: planning advice [online] Available at: https://www.gov.scot/publications/onshore-wind-turbines-planning-advice/

The Scottish Government (1996). Planning Advice Note 50: controlling the environmental effects of surface mineral workings. [online] Available at: https://www.gov.scot/publications/planning-advice-note-pan-50-controlling-environmental-effects-surface-mineral/

British Standards Institute (2014). BS 82331, Guidance on sound insulation and noise reduction for buildings. BSI

Berglund, B., Lindvall, T., Schwela, Dietrich H and World Health Organization. Occupational and Environmental Health Team (1999). Guidelines for community noise. [online] Available at: https://apps.who.int/iris/handle/10665/66217.

Environmental Protection Agency (2011). Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3). [online] www.epa.ie. Available at: https://www.epa.ie/publications/monitoring--assessment/noise/guidance-note-on-noise-assessment-of-wind-turbine-operations-at-epa-licensed-sites-ng3.php#:~:text=Circular%20Economy-,Guidance%20Note%20on%20Noise%20Assessment%20of%20Wind%20Turbine%20Operations%20at,with%20respect%20to%20noise%20nuisance.

Health Effects of Exposure to Ultrasound and Infrasound Report of the independent Advisory Group on Non-ionising Radiation. (n.d.). Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/335014/RCE-14_for_web_with_security.pdf.

Infrasound levels near windfarms and in other environments. (n.d.). Available at: https://www.epa.sa.gov.au/files/477912_infrasound.pdf

Environmental Protection Agency (2016). Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4). [online] Available at: https://www.epa.ie/publications/monitoring--assessment/noise/guidance-note-for-noise-licence-applications-surveys-and-assessments-in-relation-to-scheduled-activities-ng4.php

Moorhouse, A.T., Waddington, D.C. and Adams, M.D. (2009). A procedure for the assessment of low frequency noise complaints. The Journal of the Acoustical Society of America, [online] 126(3), pp.1131–1141. Available at: https://doi.org/10.1121/1.3180695

INSTITUTE OF ACOUSTICS IOA Noise Working Group (Wind Turbine Noise) Amplitude Modulation Working Group Final Report A Method for Rating Amplitude Modulation in Wind Turbine Noise. (2016). Available at: https://www.ioa.org.uk/sites/default/files/AMWG%20Final%20Report-09-08-2016_0.pdf

REPORT for Summary of Research into Amplitude Modulation of Aerodynamic Noise from Wind Turbines. (Dani Fiumicelli). Available at: https://cdn.ymaws.com/www.renewableuk.com/resource/collection/4E7CC744-FEF2-473B-AF2B-135FF2AA3A43/summary_of_research_into_am_(1).pdf

Moorhouse, Andy & Hayes, M & Von Hunerbein, Sabine & Piper, Ben & Adams, Mags. (2007). Research into aerodynamic modulation of wind turbine noise: final report.

Davis R A, Dr Lower MC. (1996) Noise Measurements in Windy Conditions ETSU W/13/00386/REP ISVR Consultancy Services, University of Southampton