11 Acoustic Assessment

11.1 Introduction

11.1.1 This chapter considers the likely significant acoustic effects associated with the construction, operation and decommissioning of the proposed Killean Wind Farm (hereafter referred to as the Proposed Development) on residents of nearby properties. The specific objectives of the chapter are to:

- describe the current baseline;
- describe the assessment methodology and significance criteria used in completing the impact assessment;
- describe the potential effects, including direct, indirect and cumulative effects;
- describe the mitigation measures proposed to address the likely significant effects; and
- assess the residual effects remaining following the implementation of mitigation measures.

11.1.2 This assessment has been undertaken by Renewable Energy Systems Ltd (RES) (hereafter referred to as the Applicant), with three in-house Members of the Institute of Acoustics involved in its production. The Applicant has undertaken acoustic impact assessments in every single one of its UK wind farm development applications since 2000. The Applicant has also carried out noise assessments and reported to several local planning authorities on operational wind energy projects, including taking measurements on newly constructed wind farms to ensure compliance with planning conditions.

11.1.3 The chapter author is Artem Khodov, a Member of the Institute of Acoustics with six years of experience in acoustics. The chapter was checked by Stuart Hill, a Member of the Institute of Acoustics with 10 years' experience in acoustic assessments. The chapter reviewer is Jeremy Bass, a Member of the Institute of Acoustics with over 30 years of experience in wind farm development and acoustic assessments. Further details of experience and qualifications are included in **Chapter 1: Introduction**.

11.1.4 Additionally, the Applicant has been project co-ordinator for several Joule[1] projects, leading European research into wind turbine noise, was involved in producing the guideline 'The Assessment and Rating of Noise from Wind Farms'[2] for the DTI in 1996, acted as peer reviewer for the 'Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise'[3], and contributed to the RenewableUK work on Amplitude Modulation[4]. Selected publications include:

- 'Wind Turbine Measurements for Noise Source Identification', ETSU W/13/003914/00.REP, 1999, Dr P Dunbabin, RES et al;
- 'A Critical Appraisal of Wind Farm Noise Propagation', ETSU W/13/00385/REP, 2000 Dr J Bass, RES;
- 'Aerodynamic Noise Reduction for Variable Speed Turbines', ETSU/W/45/00504/REP, 2000, Dr P Dunbabin, RES;
- 'Fundamental research in amplitude modulation - a project by RenewableUK', Dr J Bass et al, Fourth International Meeting on Wind Turbine Noise, Rome, April 2011;
- 'Investigation of the 'Den Brook' Amplitude Modulation methodology for wind turbine noise', Dr J Bass, Acoustics Bulletin Vol 36 No 6 November/December 2011;
- 'How does noise influence the design of a wind farm?', Dr M Cassidy, Fifth International Conference on Wind Turbine Noise, Denver, 2013;
- 'Propagation of Noise from Wind Farms According to the Good Practice Guide', A Birchby, Sixth International Conference on Wind Turbine Noise, Glasgow, 2015; and
- 'A Method for Rating Amplitude Modulation in Wind Turbine Noise', Institute of Acoustics Noise Working Group, August 2016.

11.1.5 The chapter is supported by:

[1] DGXII European Commission funded projects in the field of Research and Technological Development in non-nuclear energy

[2] 'The Assessment and Rating of Noise from Wind Farms', The Working Group on Noise from Wind Turbines, ETSU Report for the DTI, ETSU-R-97, September 1996. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/49869/ETSU_Full_copy__Searchable_.pdf

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

[4] 'Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effects', RenewableUK, December 2013. Available at: http://usir.salford.ac.uk/id/eprint/33475/

- Figure 11.1 – Predicted Sound Footprint;
- Technical Appendix 11.1 – Issues Scoped Out of Wind Farm Noise Assessment;
- Technical Appendix 11.2 – Calculating Standardised Wind Speed;
- Technical Appendix 11.3 – Background Sound Survey Photos;
- Technical Appendix 11.4 – Instrumentation Records;
- Technical Appendix 11.5 – Charts; and
- Technical Appendix 11.6 – Suggested Planning Conditions.

11.1.6 **Figure 11.1** and Technical Appendices are referenced in the text where relevant.

11.2 Legislation, Policy and Guidance

Operational Noise

11.2.1 In the context of other sources of environmental noise, the noise levels produced by wind turbines are generally low and have greater dependence upon wind speed. The combination of these two factors implies that a degree of masking would often be provided by background noise.

11.2.2 As described by Scottish Government Planning Advice for Onshore Wind Turbines[5]:

"Technically, there are two quite distinct types of noise sources within a wind turbine - 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. There has been significant reduction in the mechanical noise generated by wind turbines through improved turbine design."

11.2.3 Within Scotland, noise is defined within the planning context by 'Planning Advice Note 1/2011: Planning and Noise'[6]. This Planning Advice Note provides advice on the role of the planning system in helping to prevent and limit the adverse effects of noise. The Planning Advice Note 1/2011 states that:

[5] 'Onshore wind turbines: planning advice', Scottish Government, May 2014. Available at: https://www.gov.scot/publications/onshore-wind-turbines-planning-advice/

[6] 'Planning Advice Note 1/2011: Planning and Noise', Scottish Government, March 2011. Available at: https://www.gov.scot/publications/planning-advice-note-1-2011-planning-noise/

"Good acoustical design and siting of turbines is essential to minimise the potential to generate noise."

11.2.4 Planning Advice Note 1/2011 refers to the use of the Department of Trade and Industry's 'The Assessment and Rating of Noise from Wind Farms' (ETSU-R-97), noting that further guidance is provided in the web-based planning advice on renewable technologies for onshore wind turbines[7]. In relation to noise from wind farms the web-based renewables advice states:

" *'The Assessment and Rating of Noise from Wind Farms' provides a framework for the measurement of wind farm noise, noise, and all applicants are required to follow the framework and use it to assess and rate noise from wind energy developments…until such time as new guidance is produced"., until such time as an update is available."*

11.2.5 It is therefore considered that the use of ETSU-R-97, as criteria for assessment of wind farm noise, fulfils the requirements of Planning Advice Note 1/2011.

11.2.6 The methodology described in ETSU-R-97 was developed by a working group comprised of a cross-section of interested persons including, amongst others, environmental health officers, wind farm operators and independent acoustic experts.

11.2.7 ETSU-R-97 makes it clear from the outset that any noise restrictions placed on a wind farm must balance the environmental impact of the wind farm against the national and global benefits that arise through the development of renewable energy resources. The principle of balancing development needs against protection of amenity may be considered common to any type of noise control guidance.

11.2.8 The basic aim of ETSU-R-97, in arriving at the recommendations contained within the report, is the intention to provide:

[7] Scottish Government (2022). Onshore wind: Policy Statement. Scottish Government. Available at: https://www.gov.scot/publications/onshore-wind-policy-statement-2022/

"Indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities."

11.2.9 An article published in the Institute of Acoustics (IoA) Bulletin Vol. 34 No. 2, March/April 2009[8], recommends a methodology for addressing issues not made explicit by, or outside the scope of, ETSU-R-97, such as in relation to wind shear or noise propagation modelling. Whilst this article does not represent formal legislation or guidance it was authored by a group of independent acousticians experienced in wind farm noise issues who have undertaken work on behalf of wind farm developers, local planning authorities and third parties and as such is a good indicator of best practice techniques. The assessment presented herein adopts the recommendations made within this article.

11.2.10 A Good Practice Guide (GPG) to the application of ETSU-R-97 for the assessment and rating of wind turbine noise[9], issued by the Institute of Acoustics (IoA) in May 2013 and endorsed by the Northern Ireland Executive, along with the governments in England, Scotland and Wales, provides guidance on all aspects of the use of ETSU-R-97 and reaffirms the recommendations of the Acoustics Bulletin article with regard to propagation modelling and wind shear. The assessment presented herein adopts the recommendations of the GPG.

11.2.11 Supplementary guidance notes were published by the IoA in July and September 2014, and these provide further details on specific areas of the IoA GPG. The assessment presented herein adopts the recommendations made within these supplementary guidance notes.

11.2.12 ETSU-R-97 has been applied at the vast majority of wind farms currently operating in the UK and provides a robust basis for assessing the noise impact of a wind farm when used in accordance with the IoA GPG. It is the only relevant guidance referenced in

[8] 'Prediction and Assessment of Wind Turbine Noise', Bowdler et al, Acoustics Bulletin Vol 34 No 2 March/April 2009

[9] 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise - Supplementary Guidance Notes', Institute of Acoustics, July & September 2014. Available at https://www.ioa.org.uk/publications/wind-turbine-noise

Scottish Planning Policy (2014) for rating and assessing operational wind farm noise. Based on planning policy and guidance, as outlined above, a wind farm which can operate within noise limits derived according to ETSU-R-97 shall be considered acceptable. This approach has been agreed with the ECU.

Construction Noise

11.2.13 In the web based Scottish Government technical advice on construction noise assessment in 'Appendix 1: Legislative Background, Technical Standards and Codes of Practice'[10] it is stated that:

"However, under Environmental Impact Assessments and for planning purposes i.e. not in regard to the Control of Pollution Act 1974, the 2009 version of BS 5228 is applicable."

11.2.14 Given that BS 5228-1:2009+A1:2014 'Code of practice for noise and vibration control on construction and open sites - Part 1: Noise'[11] is identified as being the appropriate source of guidance on appropriate methods for minimising noise from construction activities, it is adopted herein.

11.2.15 The Control of Pollution Act 1974 provides information on the need for ensuring that the best practicable means are employed to minimise noise[12].

11.2.16 BS 5228-2:2009+A1:2014 'Code of practice for noise and vibration control on construction and open sites - Part 2: Vibration'[13], provides a method for predicting vibration levels which has been adopted in this assessment.

11.2.17 BS 6472-2:2008 'Guide to evaluation of human exposure to vibration in buildings - Part 2: Blast-induced vibration'[14] has been used to set

[10] 'Assessment of noise: technical advice note', Scottish Government, March 2011. Available at: http://www.gov.scot/publications/technical-advice-note-assessment-noise/

[11] 'Code of Practice for Noise and vibration control on construction and open sites - Part 1: Noise', British Standards Institution, BS 5228-1:2009+A1:2014

[12] 'Control of Pollution Act', published by Her Majesty's Stationary Office, July 1974. Available at: https://www.legislation.gov.uk/ukpga/1974/40

[13] 'Code of Practice for Noise and vibration control on construction and open sites - Part 2: Vibration', British Standards Institution, BS 5228-2:2009+A1:2014

[14] 'Guide to evaluation of human exposure to vibration in buildings. Blast-induced vibration', BS 6472-2:2008

criteria for satisfactory magnitudes of vibration at nearby residential properties to ensure compliance with respect to human response.

11.3 Consultation

11.3.1 Details of the consultation undertaken are outlined in **Table 11.1**.

Table 11.1: Acoustic Assessment Consultation

Consultees	Date of Consultation	Nature and Purpose of Consultation
Energy Consents Unit	01/09/23	Scoping Report submitted (ECU reference ECU00004927), detailing proposed assessment methodology.
Energy Consents Unit	28/11/23	Scoping Opinion that noise assessment should be carried out in line with the legislation and standards outlined in the Scoping Report. Scoping Opinion did not include an opinion from the Argyll and Bute Council Environmental Health Department. This still has not been received.
Argyll and Bute Council	26/01/2024	Email from RES Acoustics team to the Environmental Health Officers of Argyll and Bute Council, outlining the proposed methodology and seeking commentary, if any. The email was never responded to.

11.4 Methodology

Scope of Assessment

11.4.1 Noise can have an effect on the environment and on the quality of life enjoyed by individuals and communities. The effect of noise, both in the construction and operational phase, is therefore a material consideration in the determination of planning applications.

Operation

11.4.2 To ensure adequate assessment of the potential impacts of the operational noise from the Proposed Development the following steps have been taken, in accordance with relevant guidance detailed above:

- The baseline noise conditions at each of the nearest residential properties to the Proposed Development are established by way of representative background sound surveys;
- The noise levels at the nearest residential properties from the operation of the Proposed Development are predicted using a

sound propagation model considering: the locations of the wind turbines; the intervening terrain; and the likely noise emission characteristics of the wind turbines;

- The acoustic assessment criteria are derived appropriately; and
- The evaluation of the acoustic impact is undertaken by comparing the predicted noise levels with the assessment criteria. Significant effects in terms of the EIA regulations would be identified if the predicted noise levels exceed limits derived in accordance with ETSU-R-97. Significant effects would not be expected should the predicted noise levels be less or equal than the ETSU-R-97 limit.

11.4.3 Aerodynamic and mechanical noise are scoped into the operational noise assessment. The main focus of the assessment of operational noise presented here is based on the most relevant type of noise emission for modern wind turbines: aerodynamic noise, which is broadband in nature. Mechanical noise, which can be tonal in nature, is also considered albeit less relevant to modern wind turbines whose improved design has led to significant reductions in mechanical noise. Implicitly incorporated within this assessment is the normal character of the noise associated with wind turbines (commonly referred to as 'blade swish') and consideration of a range of noise frequencies, including low frequencies.

11.4.4 Low frequency content of the noise from wind farms shall be considered through the use of octave band specific noise emission and propagation modelling, however it is considered that specific and targeted assessment on low frequency content of noise emissions from the Proposed Development is unjustified. Details for scoping out low frequency noise from the operational noise assessment, as well as infrasound, sleep disturbance, vibration, amplitude modulation and wind turbine syndrome can be found in **Technical Appendix 11.1.**

11.4.5 A summary of the findings of a comprehensive study into wind turbine noise and associated health effects can be found in **Technical Appendix 11.1.**

Construction

11.4.6 The construction of wind turbines, ancillary electrical equipment, compounds and the corresponding access tracks typically occurs at very large distances from neighbouring residential properties. The resultant noise and vibration, which would be temporary in nature, is only very rarely a cause for concern in terms of the potential for disturbing the inhabitants of neighbouring residential properties. Whilst the noise associated with the construction of these aspects may well be audible to people residing in the area, the levels would be below established noise limits and planning requirements in this respect. Nevertheless, typical mitigation measures, including the use of 'best practicable means' would be incorporated into the construction practices for the Proposed Development with a view to reducing noise levels where possible and practical. As a result, this aspect is discussed in generalised terms with reference to standard noise limiting requirements; typical working practices; hours of work, and standard mitigation measures in this respect. A detailed assessment has not been undertaken and a similar rationale can be applied for noise impacts associated with decommissioning of the Proposed Development.

11.4.7 Construction relating to the provision of access to the site, including the upgrade of public roads and their use thereof, may well occur at locations near to residential properties. As a result, and in instances where this is likely to occur, consideration of enhanced mitigation measures which would be reasonably possible to implement, have been discussed. In any event, typical noise limiting requirements would apply and the contractor undertaking the works would be responsible for potential issues and taking appropriate and reasonable steps to address these should they occur. As a result, this aspect is also discussed in generalised terms and a detailed assessment has not been undertaken as this would require a detailed construction plan to provide confidence in the results, which is not available at this time. However, certain details as to construction practices would be provided within a Construction Environmental Management Plan (CEMP), with reference to potential noise and vibration impacts, where necessary. An outline CEMP has been provided in **Technical Appendix 2.1**.

11.4.8 Noise and vibration associated with the movement of additional vehicles, including heavy goods vehicles (HGVs) along public roads and access routes may well be noticeable to residents adjacent to these. However, this would essentially only result in a minor increase in the average noise levels from existing public roads, with the most noticeable noise and perceptible vibration effects resulting from the sporadic and increased number of HGV pass-bys at residential properties along the access routes, with resulting levels for individual events being similar to that created by existing HGV movements.

11.4.9 In order to release materials at proposed borrow-pit locations, the use of specifically designed explosives may be used, this is also known as blasting. The resultant noise, vibration and air overpressure from blasting cannot be reliably predicted. However, these aspects may well be perceptible to neighbouring residents. The vibration generated by each blast would be well below levels that would be expected to cause damage to the nearest housing and/or structures nearby. As a result, the impacts resulting from blasting is not considered in any detail other than the provision of discussion as to the steps to limit any resulting impact through appropriate blast design and best practice, which also involves keeping residents informed as to planned blasting activities.

Decommissioning

11.4.10 Whilst noise would also arise during decommissioning of the Proposed Development (through wind turbine deconstruction and breaking of the exposed part of the concrete bases) this is not discussed separately as noise levels resulting from it are expected to be lower than those during construction due to the number and type of activities involved.

Baseline Characterisation

11.4.11 Similar to other assessments of acoustic impacts (most notably BS 4142 , which ETSU R-97 identifies as forming the basis of its recommendations), the ETSU-R-97 methodology requires the comparison of predicted noise levels due to wind turbine emissions (which vary with hub height wind speed) with noise limits based upon

the noise levels already existing under those same conditions (i.e. the baseline conditions).

11.4.12 Since background sound levels depend upon wind speed, as indeed do wind turbine noise emissions, it is important when making reference measurements to put them in that context. Thus, the assessment of background sound levels requires the measurement of not only noise levels, but concurrent wind conditions, covering a representative range of wind speeds. These wind measurements are made at the site rather than at the residential properties, since it is this wind speed that would subsequently govern the Proposed Development's noise generation. Often the residential properties themselves will be sheltered from the wind and may consequently have relatively low background sound levels.

11.4.13 To establish the baseline conditions, sound level meters and associated apparatus are set-up to record the required acoustic information at a selection of the nearest residential properties geographically spread around the Proposed Development and which are likely to be representative of other residential properties in the locale.

11.4.14 Wind speed and direction are recorded as 10-minute averages for the same period as for the sound measurements and are synchronised with the acoustic data to allow correlations to be established. The wind speed that is adopted for use is the same wind speed as that which drives the wind turbine noise levels.

11.4.15 The adoption of this wind speed was recommended within the IoA GPG. The methodology used to calculate standardised 10m wind speed is described in **Technical Appendix 11.2.**

11.4.16 Prior to establishing the baseline conditions the acoustic data is filtered as follows:

11.4.17 For each background sound measurement location, the measured noise data is divided into two sets, as specified by ETSU-R-97 and shown in **Table 11.2**:

Table 11.2: Definition of Time-of-Day Periods

Time of Day	Definition
Quiet daytime	08:00 - 23:00 every day 13:00 - 18:00 Saturday 07:00 - 18:00 Sunday
Night-time	23:00 - 07:00 every day

11.4.18 Rainfall affected data is systematically removed from the acoustic data set. To facilitate this, a rain gauge is deployed to record 10-minute rainfall data and identify potentially affected acoustic data. Both the 10-minute period containing the bucket tip and the preceding 10-minute period are removed from the dataset as recommended in the IoA GPG to account for the time it takes for the rain gauge tipping bucket to fill.

11.4.19 Periods of measured background noise data thought to be affected by extraneous, i.e. non-typical, noise sources are identified and removed from the data set. Whilst some 'extraneous' data may actually be real, it tends to bias any trend lines upwards, so its removal is adopted as a conservative measure.

11.4.20 In practice this means close inspection of the measured background noise levels, comparison with concurrent data measured at nearby locations and consideration of both directional and temporal variation.

Modelling Noise Propagation

11.4.21 Whilst there are several sound propagation models available, the ISO 9613 Part 2 model has been used, this being identified as most appropriate for use in such rural sites. The specific interpretation of the ISO 9613 Part 2 propagation methodology recommended in the aforementioned IoA Bulletin and the subsequent IoA GPG has been employed.

11.4.22 To make noise predictions it is assumed that:

- the wind turbines have the Sound Power Level (SWL) specified in this report;
- each wind turbine can be modelled as a point source at hub-height; and

- each residential property is assigned a reference height to simulate the presence of an observer.

11.4.23 The sound propagation model takes account of attenuation due to geometric spreading and atmospheric absorption. The assumed temperature and relative humidity are 10˚C and 70% respectively, as recommended in the IoA Bulletin and IoA GPG. Ground effects are also taken into account by the propagation model with a ground factor of 0.5 and a receiver height of 4m used as recommended in the IoA Bulletin and IoA GPG.

11.4.24 The barrier attenuations predicted by ISO 9613 Part 2 have been shown to be significantly greater than those measured in practice under downwind conditions. Therefore, barrier attenuation according to the ISO 9613 Part 2 method has been discounted. In lieu of this, where there is no direct line of sight between the residential property in question and any part of the wind turbine, 2dB attenuation has been assumed as recommended in the IoA Bulletin and the IoA GPG.

11.4.25 Additionally, verification studies have also shown that ISO 9613 Part 2 tends to slightly underestimate noise levels at nearby dwellings in certain exceptional cases, notably in a valley type environment where the ground drops off between source and receiver. In these instances, an addition of 3dB(A) has been applied to the resulting overall a weighted noise level as recommended by the IoA GPG.

11.4.26 To generate the ground cross sections between each wind turbine and each dwelling necessary for reliable propagation modelling, ground contours at 5m intervals for the area of interest have been generated from 50m grid resolution digital terrain data.

11.4.27 The predicted noise levels are calculated as L_{Aeq} noise levels and changed to the L_{A90} descriptor (to allow comparisons to be made) by subtraction of 2dB, as specified by ETSU-R-97.

11.4.28 It has been shown by measurement-based verification studies that the ISO 9613 Part 2 model tends to slightly overestimate noise levels at nearby dwellings. Examples of additional conservative assumptions modelled are:

- properties are assumed to be downwind of all noise sources simultaneously and at all times. In reality, this is not the case and additional attenuation would be expected when a property is upwind or crosswind of the proposed wind turbines;
- although, in reality, the ground is predominantly porous (acoustically absorptive) it has been modelled as 'mixed', i.e. a combination of hard and porous, corresponding to a ground absorption coefficient of 0.5 as recommended by the IoA Bulletin and IoA GPG;
- receiver heights are modelled at 4m above local ground level, which equates roughly to first floor window level, as recommended by the IoA Bulletin and IoA GPG. This results in a predicted noise level anything up to 2dB(A) higher than at the typical human ear height of 1.2m – 1.8m;
- trees and other non-terrain shielding effects have not been considered;
- an allowance for measurement uncertainty has been included in the sound power levels for the presented candidate wind turbine.

11.4.29 The locations of the turbines which make up the Proposed Development are provided in **Table 11.3** and shown in **Figure 11.1**. All coordinates are according to Ordnance Survey of Great Britain, 1936 (EPSG code 27700).

Table 11.3: Location of Proposed Wind Turbines

Wind Turbine	Co-ordinates		Wind Turbine	Co-ordinates		Wind Turbine	Co-ordinates	
	X (m)	Y (m)		X (m)	Y (m)		X (m)	Y (m)
T1	172751	645348	T4	172444	644554	T7	172456	643536
T2	173196	644486	T5	172481	644073	T8	171960	643770
T3	173046	644942	T6	173006	643877	T9	171954	645466

11.4.30 The locations of the nearest residential properties to the wind turbines have been determined by inspection of relevant maps and through site visits. The study area has been determined in accordance with guidance provided in IoA GPG. More residential properties may have been identified but have not been considered

critical to this acoustic assessment or may be adequately represented by another residential property. The locations considered are listed in **Table 11.4** and are also shown in **Figure 11.1.**

11.4.31 The distances from each residential property to the nearest wind turbine are given in **Table 11.4**. It can be seen that the minimum house-to-wind turbine separation is 1,753 m to H12 (4 Largie).

Table 11.4 - Location of Residential Properties and Distances to Nearest Proposed Wind Turbine

House ID	House Name	Co-ordinates		Distance (m)	Nearest Wind Turbine
		X (m)	Y (m)		
H1	NORTH CRAIGRUADH	169202	643733	2,758	T8
H2	KILMORY	170052	644958	1,969	T9
H3	OLD MISSION HOUSE RHUNAHAORINE	170784	648436	3,192	T9
H4	SCHOOLHOUSE RHUNAHAORINE	170662	648110	2,943	T9
H5	GORTINANANE HOUSE	170598	647455	2,407	T9
H6	TAVANTAGGART	170398	646706	1,989	T9
H7	CRUACHAN	169614	645142	2,362	T9
H8	HIGH DUNASHERY LARGIEHILL	170699	647843	2,688	T9
H9	GORTINANANE FARM COTTAGE	170710	647555	2,431	T9
H10	GIGHA VIEW	170335	647053	2,267	T9
H11	NORTH COTTAGE RHUNAHAORINE	170811	648499	3,241	T9
H12	4 LARGIE	170302	646052	1,753	T9
H13	MACJUCOL COTTAGE	169001	643377	2,985	T8
H14	CULFUAR	170098	645411	1,857	T9
H15	DRUMNAMUCKLACH	169652	643944	2,315	T8
H16	BEACHAR	169345	643214	2,673	T8
H17	KENNELS LARGIE	170275	646018	1,767	T9
H18	JURA KILLEAN	169948	644450	2,124	T8
H19	RHUNAHAORINE SCHOOL	170671	648123	2,950	T9
H20	GALLERY RHUNAHAORINE	170781	648430	3,187	T9
H21	KILLEAN HOUSE	169662	644282	2,354	T8

House ID	House Name	Co-ordinates		Distance (m)	Nearest Wind Turbine
		X (m)	Y (m)		
H22	TAYINLOAN FILLING STATION	169781	645912	2,218	T9
H23	RHUNAHAORINE COTTAGE	170750	648410	3,180	T9
H24	BEACHMENACH	168865	642759	3,256	T8
H26	HIGH CRUBASDALE FARM	171862	644779	4,251	T8
H27	SOUTH BEACHMORE FARM	169076	640647	4,096	T8
H28	HIGH CLACHAIG	168583	641452	3,530	T8
H29	NORTH BEACHMORE	169985	640844	3,536	T8
H30	NORTH CRUBASDALE FARM	168927	641953	4,171	T8

11.5 Acoustic Impact Criteria

Operational Noise Impact

11.5.1 Sound is measured in decibels (dB) which is a measure of the sound pressure level, i.e. the magnitude of the pressure variations in the air. Measurements of environmental noise are usually made in dB(A) which includes a correction for the sensitivity of the human ear.

11.5.2 ETSU-R-97 seeks to protect the internal and external amenity of wind farm neighbours by defining acceptable limits for operational noise from wind turbines. The test applied to operational noise is whether or not the noise levels produced by the combined operation of the wind turbines comply with noise limits derived in accordance with ETSU-R-97 at nearby residential properties.

11.5.3 Whilst ETSU-R-97 presents a comprehensive and detailed assessment methodology for wind farm noise, it also provides a simplified methodology: *"if the noise is limited to an $L_{A90,10min}$ of 35dB(A) up to wind speeds of 10m/s at 10m height, then these conditions alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary"*.

11.5.4 In the detailed methodology, ETSU-R-97 states that different limits should be applied during daytime and night-time periods. The daytime limits, derived from the background noise levels measured during quiet daytime periods, are intended to preserve outdoor amenity, while the night-time limits are intended to prevent sleep

disturbance. The general principle is that the noise limits should be based on existing background sound levels, except for very low background sound levels, in which case a fixed limit may be applied. The suggested limits are given in **Table 11.5** below, where L_B is the background $L_{A90,10min}$ and is a function of wind speed. During daytime periods and at low background sound levels, a lower fixed limit of 35-40dB(A) is applicable. The exact value is dependent upon a number of factors: the number of nearby dwellings, the effect of the noise limits on energy produced, and the duration and level of exposure.

Table 11.5: Permissible Noise Level Criteria

Time of Day	Definition
Quiet daytime	35-40 dB(A) for L_B less than 30-35 dB(A) L_B + 5 dB, for L_B greater than 30-35 dB(A)
Night-time	43 dB(A) for L_B less than 38 dB(A) L_B + 5 dB, for L_B greater than 38 dB(A)

11.5.5 Note that a higher noise level is permissible during the night than during the day as it is assumed that residents would be indoors. The night-time criterion is derived from sleep disturbance criterion referred to in ETSU-R-97, with an allowance of 10 dB for attenuation through an open window.

11.5.6 The wind speeds at which the acoustic impact is considered are less than or equal to 12ms^{-1} at a height of 10m and are likely to be the acoustically critical wind speeds. Above these wind speeds, as stated in ETSU-R-97, reliable measurements of background and wind turbine noise are difficult to make. However, if a wind farm meets the acoustic criteria at the wind speeds presented, it is most unlikely that it would cause any greater loss of amenity at higher wind speeds due to increasing background sound levels masking wind farm generated sound.

11.5.7 It is important to note that, since reactions to noise are subjective, it is not possible to guarantee that a given development would not result in any adverse comment with regard to noise as the response to any given noise will vary from person to person. Consequently, standards and guidance that relate to environmental noise are typically presented in terms of criteria that would be expected to be considered acceptable by the majority of the population.

Construction Noise Impact

11.5.8 Construction noise is discussed with reference to Annex E of BS 5228-1:2009+A1:2014 which provides guidance on setting environmental noise targets. Several methods of assessing the significance of noise levels are presented in Annex E and the most applicable to the construction of the Proposed Development is the ABC method.

11.5.9 The ABC method sets threshold noise levels for construction noise for specific periods based on the pre-existing ambient noise levels, subject to average lower Category A limiting values of 65, 55 and 45dB L_{Aeq} for daytime (07:00 - 19:00 weekdays and Saturdays 07:00 – 13:00), evenings and weekends (19:00 – 23:00 weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays) and night-time (23:00 – 07:00) periods respectively, for instances where existing ambient noise levels are relatively low, which is the case here.

11.5.10 BS 5228-2:2009+A1:2014 provides guidance on the assessment of vibration due to blasting. A scaled distance graph is shown in Figure E.1 within Annex E which provides an indication of likely vibration magnitudes at various distances. This Figure can be used to determine the level of vibration which would not be expected to be exceeded in 95% of blasts for a given distance and charge size.

11.5.11 BS 6472-2:2008 details the maximum satisfactory magnitudes for vibration measured on a firm surface outside buildings with respect to human response. For up to three blast vibration events per day, the generally accepted maximum satisfactory magnitude at residential premises during daytime periods (08:00 – 18:00 Monday to Friday and 08:00 – 13:00 on Saturdays), is a peak particle velocity (ppv) of 6.0 to 10.0 mms^{-1}. In practice, the lower satisfactory magnitude should be used with the higher magnitude being justified on a case-by-case basis.

11.5.12 Where it is considered that the levels of construction noise and vibration, including that from blasting, can meet the relevant limits for each aspect or that appropriate controls or mitigation can be put in place, the resultant impact is considered not significant.

11.6 Baseline

11.6.1 The Proposed Development is located approximately 2.5 km east of Tayinloan. The surrounding area is predominantly rural in nature and used for grazing sheep and cattle with an A-class road running to the west of the site and the sea approximately 3 km to the west. The general noise character is typical of a rural environment with noise from farm machinery, sheep, cattle, and birds.

11.6.2 Background sound measurements were undertaken at two residential property locations in accordance with ETSU R 97. These locations are detailed in **Table 11.6.**

Table 11.6 - Background Sound Survey Details

House Name	Measurement Period		
	Start	End	Duration (days)
H14 - Culfuar	25/01/2016	10/03/2016	45
H15 - Drumnamucklach	25/01/2016	10/03/2016	45

11.6.3 The background sound monitoring equipment was housed in weather-proof enclosures and powered by lead-acid batteries. The microphones were placed at a height of approximately 1.2 - 1.5m above ground and equipped with all-weather wind shields which also provide an element of water resistance.

11.6.4 The proprietary wind shields used are designed to reduce the effects of wind-generated noise at the microphone and accord with the recommendations of the IoA GPG in that they are the appropriate size and, in combination with the microphone, are certified by the manufacturer as meeting Type 1 / Class 1 precision standards.

11.6.5 Sound levels are monitored continuously, and summary statistics stored every 10 minutes in the internal memory of each meter. The relevant statistic measured is the $L_{A90,10min}$ (The A-weighted sound pressure level exceeded for 90% of the 10-minute interval).

11.6.6 The sound level meters were placed away from reflecting walls and vegetation. Photos of the equipment, in situ, may be seen in **Technical Appendix 11.3**. The apparatus were calibrated before and after the survey period and the maximum detected calibration drift

was 0.2dB, which is within the required range recommended in the IoA GPG. All instrumentation was subject to laboratory calibration traceable to national standards within the last 24 months at the time of the survey, as recommended in the IoA GPG. Details are provided in **Technical Appendix 11.4.**

11.6.7 **Chart 11.5.1** (see **Technical Appendix 11.5** for all charts) shows the measured wind rose over the background sound survey period, as measured by a LiDAR (Light Detection and Ranging) located on-site.

11.6.8 A LiDAR is a remote sensing device that measures conditions in the atmosphere by using pulses from a LASER by applying the principle of the Doppler Effect, detecting the movement of air in the atmospheric boundary layer to measure wind speed and direction. LiDAR provides measurements at several heights, and this enables wind speed data to be obtained that describe the wind profile across a range of heights.

11.6.9 LIDAR has been successfully tested, by independent third parties using suitable test sites, against conventional anemometry. From the technical reports, these tests have demonstrated that, over a range of relevant heights, the accuracy of the LIDAR is comparable to that of the conventional anemometry.

11.6.10 For illustrative purposes, **Chart 11.5.2** shows the predicted wind rose using mesoscale modelling over an extended period (one calendar year). As previously discussed, the noise prediction model employed is likely to overestimate the real noise immission levels for locations not downwind of the wind turbines. **Chart 11.5.2** therefore may aid the reader as to the likelihood of over-estimation due to this factor.

11.6.11 The acoustic data has been cross-referenced with rainfall data measured at the site using a rain gauge. Any acoustic data identified as having been affected by rainfall has been removed from the analysis as shown in **Charts 11.5.3 to 11.5.6.**

11.6.12 **Charts 11.5.3 and 11.5.4** show $L_{A90,10min}$ correlated against wind speed for quiet daytime periods at each survey location. In each case, a 'best fit' line has been fitted to the data and the noise limits added. The equation of the regression polynomial has been provided in the charts.

11.6.13 **Charts 11.5.5 and 11.5.6** show $L_{A90,10min}$ correlated against the wind speed for night-time periods at each survey location. In each case, a 'best fit' line has been fitted to the data and the noise limits added. The equation of the regression polynomial has been provided in the charts.

11.6.14 Also included within this assessment are the results for the background noise surveys which were conducted by AECOM between 09/12/15 and 07/01/16 in support of the planning application for Clachaig Glen Wind Farm[15]. The surveys were conducted in accordance with the guidance in ETSU-R-97 and the IoA GPG. The measured noise levels from the four survey locations at: Beacharr, High Crubasdale, North Beachmore and North Crubasdale are used in the analysis at these properties as this is considered more representative than inferring background noise levels from Culfuar or Drumnamucklach.

11.6.15 **Table 11.7 and Table 11.8** detail the $L_{A90,10min}$ background noise levels calculated from the derived 'best fit' lines, as described above. They are provided as sound pressure levels in dB referenced to 20 micro Pascals (see Glossary for further detail):

Table 11.7- Quiet Daytime Noise Levels (dB(A) re 20μPa)

House Name	Standardised 10m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H16 - Beacharr	15.8	27.0	34.4	38.8	40.7	41.1	40.7	40.2	40.3	41.7	45.4	51.9
H14 - Culfuar	24.0	25.7	27.3	28.8	30.3	31.9	33.7	35.7	38.0	40.7	43.8	47.6
H15 - Drumnamucklach	24.2	25.8	27.2	28.5	29.8	31.1	32.7	34.5	36.9	39.7	43.3	47.6
H27 - High Crubasdale	13.5	23.4	30.2	34.5	36.9	38.0	38.4	38.5	39.1	40.6	43.7	49.0
H29 - North Beachmore	11.2	19.9	26.7	31.7	35.4	38.0	40.1	41.8	43.6	45.8	48.7	52.7
H30 - North Crubasdale	10.0	17.8	23.9	28.4	31.8	34.4	36.4	38.2	40.0	42.3	45.3	49.4

[15] Clachaig Glen Environmental Impact Assessment Report, March 2022, ECU Reference: ECU00002103

Table 11.8 - Night-time Noise Levels (dB(A) re 20 µPa)

House Name	Standardised 10m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H16 - Beacharr	40.7	40.3	40.0	39.8	39.7	39.9	40.3	40.9	41.9	43.3	45.1	47.3
H14 - Culfuar	27.7	28.3	29.1	30.0	31.1	32.5	34.2	36.3	38.9	41.9	45.5	45.5
H15 - Drumnamucklach	28.6	28.6	28.7	29.4	30.5	32.2	34.2	36.6	39.3	42.2	45.4	45.4
H27 - High Crubasdale	13.7	23.7	30.6	35.0	37.4	38.5	38.7	38.7	39.0	40.1	42.7	47.3
H29 - North Beachmore	13.0	22.8	29.8	34.6	37.6	39.5	40.6	41.6	42.8	44.8	48.2	53.4
H30 - North Crubasdale	12.3	21.5	28.1	32.5	35.2	36.8	37.7	38.4	39.4	41.2	44.1	48.8

11.6.16 The corresponding daytime and night-time operational noise limits for the survey locations for the same range of wind speeds are provided in **Table 11.9 and Table 11.10**. In accordance with the definitions given in **Table 11.5**, operational noise limits are determined as L_B + 5 dB, with a lower fixed limit of 35 dB L_{A90} applied for quiet daytime and a lower fixed limit of 43 dB L_{A90} applied for night-time for all locations.

Table 11.9- Operational Quiet Daytime Noise Limits

House Name	Standardised 10m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H16 - Beacharr	35.0	35.0	39.4	43.8	45.7	46.1	45.7	45.2	45.3	46.7	50.4	56.9
H14 - Culfuar	35.0	35.0	35.0	35.0	35.3	36.9	38.7	40.7	43.0	45.7	48.8	52.6
H15 - Drumnamucklach	35.0	35.0	35.0	35.0	35.0	36.1	37.7	39.5	41.9	44.7	48.3	52.6
H27 - High Crubasdale	35.0	35.0	35.2	39.5	41.9	43.0	43.4	43.5	44.1	45.6	48.7	54.0
H29 - North Beachmore	35.0	35.0	35.0	36.7	40.4	43.0	45.1	46.8	48.6	50.8	53.7	57.7
H30 - North Crubasdale	35.0	35.0	35.0	35.0	36.8	39.4	41.4	43.2	45.0	47.3	50.3	54.4

Table 11.10 – Operational Night-time Noise Limits

House Name	Standardised 10m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H16 - Beacharr	45.7	45.3	45.0	44.8	44.7	44.9	45.3	45.9	46.9	48.3	50.1	52.3
H14 - Culfuar	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.9	46.9	50.5	50.5
H15 - Drumnamucklach	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.3	47.2	50.4	50.4
H27 - High Crubasdale	43.0	43.0	43.0	43.0	43.0	43.5	43.7	43.7	44.0	45.1	47.7	52.3
H29 - North Beachmore	43.0	43.0	43.0	43.0	43.0	44.5	45.6	46.6	47.8	49.8	53.2	58.4
H30 - North Crubasdale	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4	44.4	46.2	49.1	53.8

11.6.17 The recommendations of ETSU-R-97 state that where there are groups of properties that are likely to have a similar background noise environment, it is appropriate to use data from one representative location as the basis for assessment at the other properties. The survey location inferred to be representative for each property is shown in **Table 11.11**. The specific choice of survey location chosen has been made considering the distance to the nearest survey location and the likelihood of experiencing a broadly similar acoustic environment as the survey location. Where the survey results have not been inferred to be representative for a property, a 35 dB(A) daytime lower fixed limit and 43 dB(A) night-time limit have been applied at standardised 10 m wind speeds up to and including 12 ms^{-1}, according to **Table 11.2**.

11.6.18 The derived noise limits are applied to each of the assessment locations identified in **Table 11.11** based on the relative proximity of the monitoring location to the assessment locations. Where there is ambiguity in this respect, the applied noise limits are applied on a basis that is considered conservative.

Table 11.11: Application of Noise Limits

House name	OSGB Co-Ordinates		Applied Noise Limit
	X (m)	Y (m)	
H1 – North Craigruadh	169202	643733	H15 - Drumnamucklach
H2 – Kilmory	170052	644958	H16 - Beacharr
H6 – Tavantaggart	170398	646706	H14 - Culfuar
H14 – Culfuar	170098	645411	H14 - Culfuar
H15 - Drumnamucklach	169652	643944	H15 - Drumnamucklach
H16 - Beacharr	169345	643214	H16 - Beacharr
H19 – Rhunahaorine School	170671	648123	H14 - Culfuar
H26 - High Crubasdale Farm	169076	640647	H26 - High Crubasdale Farm
H28 – Hich Clachaig	169985	640844	H30 - North Crubasdale
H29 - North Beachmore	168927	641953	H29 - North Beachmore
H30 - North Crubasdale	168736	641124	H30 - North Crubasdale

11.6.19 **Table 11.12** and **Table 11.13** show the corresponding daytime and night-time noise limits respectively at the residential assessment locations considered here. These limits are intended to apply to the combined impact of the Proposed Development with other existing, planned or permitted developments near the site for the purposes of assessing the overall planning acceptability in terms of wind farm operational noise.

11.6.20 Where the survey results have not been inferred to be representative for a property, a 35 dB(A) daytime lower fixed limit and 43 dB(A) night-time limit have been applied at standardised 10 m wind speeds up to and including 12 ms^{-1} according to **Table 11.12** and **Table 11.13**.

Table 11.12- Overall Daytime Noise Limits

House ID	Standardised 10m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H1	35.0	35.0	35.0	35.0	35.0	36.1	37.7	39.5	41.9	44.7	48.3	52.6
H2	35.0	35.0	39.4	43.8	45.7	46.1	45.7	45.2	45.3	46.7	50.4	56.9
H3	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H4	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H5	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H6	35.0	35.0	35.0	35.0	35.3	36.9	38.7	40.7	43.0	45.7	48.8	52.6
H7	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H8	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H9	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H10	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H11	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H12	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H13	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H14	35.0	35.0	35.0	35.0	35.3	36.9	38.7	40.7	43.0	45.7	48.8	52.6
H15	35.0	35.0	35.0	35.0	35.0	36.1	37.7	39.5	41.9	44.7	48.3	52.6
H16	35.0	35.0	39.4	43.8	45.7	46.1	45.7	45.2	45.3	46.7	50.4	56.9
H17	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H18	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H19	35.0	35.0	35.0	35.0	35.3	36.9	38.7	40.7	43.0	45.7	48.8	52.6
H20	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H21	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H22	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H23	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H24	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H26	35.0	35.0	35.2	39.5	41.9	43.0	43.4	43.5	44.1	45.6	48.7	54.0
H27	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
H28	35.0	35.0	35.0	35.0	36.8	39.4	41.4	43.2	45.0	47.3	50.3	54.4
H29	35.0	35.0	35.0	36.7	40.4	43.0	45.1	46.8	48.6	50.8	53.7	57.7
H30	35.0	35.0	35.0	35.0	36.8	39.4	41.4	43.2	45.0	47.3	50.3	54.4

Table 11.13 – Overall Night-time Noise Limits

House Name	Standardised 10m Wind Speed (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H1	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.3	47.2	50.4	50.4
H2	45.7	45.3	45.0	44.8	44.7	44.9	45.3	45.9	46.9	48.3	50.1	52.3
H3	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H4	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H5	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H6	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.9	46.9	50.5	50.5
H7	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H8	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H9	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H10	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H11	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H12	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H13	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H14	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.9	46.9	50.5	50.5
H15	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	44.3	47.2	50.4	50.4
H16	45.7	45.3	45.0	44.8	44.7	44.9	45.3	45.9	46.9	48.3	50.1	52.3
H17	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H18	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H19	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.9	46.9	50.5	50.5
H20	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H21	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H22	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H23	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H24	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H26	43.0	43.0	43.0	43.0	43.0	43.5	43.7	43.7	44.0	45.1	47.7	52.3
H27	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
H28	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4	44.4	46.2	49.1	53.8
H29	43.0	43.0	43.0	43.0	43.0	44.5	45.6	46.6	47.8	49.8	53.2	58.4
H30	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.4	44.4	46.2	49.1	53.8

Future Baseline

11.6.21 The baseline conditions would not be expected to change under the "do nothing" scenario i.e. in the event that the Proposed Development does not go ahead.

11.7 Assessment of potential effects

Operational Effects

Noise Propagation Modelling

11.7.1 Although not finalised, the candidate wind turbine type used for the purposes of the acoustic assessment of the Proposed Development is the Siemens-Gamesa SG 6.6-155 6.6MW machine. This report uses the acoustic data from the manufacturer's performance specification for this machine for all analysis. The manufacturer has identified these values as warranted although no independent test reports are available to indicate whether any margin has been incorporated. A 2dB allowance for uncertainty has therefore been added to the warranted levels as a conservative measure as recommended by the IoA GPG. Details used in this analysis are as follows:

- hub height of 102.5m;
- a rotor diameter of 155m;
- sound power levels, L_{WA}, for standardised 10m height wind speeds (v_{10}) as shown in **Table 11.14**;
- octave band sound power level data, at the wind speeds where it is available, as shown in **Table 11.15**; and
- tonal emission characteristics such that no clearly audible tones are present at any wind speed.

Table 11.14 – A-Weighted Sound Power Levels (dB(A) re 1 pW) for the Siemens-Gamesa SG 6.6-155 6.6MW Wind Turbine , including 2dB uncertainty.

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	102.5 m Hub Height
1	95.2
2	95.2
3	95.2
4	99.9
5	104.7
6	106.8
7	107.0
8	107.0
9	107.0
10	107.0
11	107.0
12	107.0

Table 11.15 - Octave Band A-Weighted Sound Power Levels (dB(A) re 1 pW) at Standardised 10m Height Wind Speeds for the Siemens-Gamesa SG 6.6-155 6.6MW Wind Turbine.

Octave Band (Hz)	$8ms^{-1}$
63	75.5
125	87.8
250	95.7
500	98.1
1000	97.6
2000	101.0
4000	101.8
8000	97.0

11.7.2 The turbine model is assumed not to have any tonal noise output that would attract a penalty at neighbouring residences as per the requirements of ETSU-R-97. Nevertheless, a warranty or guarantee would be obtained from the manufacturer which limits the level of tonal noise associated with the operation of the individual turbines (or the site as a whole), should the site be granted planning consent, and a finalised turbine model is procured. This would also help to

provide appropriate recourse with the turbine manufacturer should a tonal character be present in the noise generated by the site.

Predictions of Noise Levels at Residential Properties

11.7.3 **Table 11.16** shows the predicted noise immission levels at the nearest residential properties at each wind speed considered, calculated from the operation of the Proposed Development. The property with the highest predicted noise immission level of 29.2 dB(A) is H2 (Kilmory).

11.7.4 **Figure 11.1** shows an isobel (i.e. noise contour) plot for the Proposed Development at a 10m height wind speed of 8ms^{-1}. Such plots are useful for evaluating the noise 'footprint' of a given development.

Table 11.16: Predicted Noise Levels at Nearby Residential Properties, dB(A)

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H1	11.9	11.9	11.9	16.6	21.3	23.4	23.7	23.7	23.7	23.7	23.7	23.7
H2	17.4	17.4	17.4	22.2	26.9	29.0	29.2	29.2	29.2	29.2	29.2	29.2
H3	10.0	10.0	10.0	14.7	19.5	21.6	21.8	21.8	21.8	21.8	21.8	21.8
H4	11.7	11.7	11.7	16.5	21.2	23.3	23.5	23.5	23.5	23.5	23.5	23.5
H5	12.7	12.7	12.7	17.4	22.1	24.2	24.5	24.5	24.5	24.5	24.5	24.5
H6	14.9	14.9	14.9	19.7	24.4	26.5	26.7	26.7	26.7	26.7	26.7	26.7
H7	14.5	14.5	14.5	19.3	24.0	26.1	26.3	26.3	26.3	26.3	26.3	26.3
H8	11.0	11.0	11.0	15.7	20.4	22.5	22.8	22.8	22.8	22.8	22.8	22.8
H9	11.9	11.9	11.9	16.6	21.4	23.5	23.7	23.7	23.7	23.7	23.7	23.7
H10	14.4	14.4	14.4	19.1	23.8	25.9	26.2	26.2	26.2	26.2	26.2	26.2
H11	9.9	9.9	9.9	14.6	19.3	21.4	21.7	21.7	21.7	21.7	21.7	21.7
H12	15.1	15.1	15.1	19.8	24.5	26.6	26.9	26.9	26.9	26.9	26.9	26.9
H13	11.0	11.0	11.0	15.7	20.4	22.5	22.8	22.8	22.8	22.8	22.8	22.8
H14	15.9	15.9	15.9	20.6	25.4	27.5	27.7	27.7	27.7	27.7	27.7	27.7
H15	14.4	14.4	14.4	19.1	23.8	25.9	26.2	26.2	26.2	26.2	26.2	26.2
H16	12.5	12.5	12.5	17.2	21.9	24.0	24.3	24.3	24.3	24.3	24.3	24.3
H17	15.0	15.0	15.0	19.7	24.5	26.6	26.8	26.8	26.8	26.8	26.8	26.8
H18	15.5	15.5	15.5	20.3	25.0	27.1	27.3	27.3	27.3	27.3	27.3	27.3
H19	11.7	11.7	11.7	16.4	21.2	23.3	23.5	23.5	23.5	23.5	23.5	23.5
H20	10.0	10.0	10.0	14.7	19.5	21.6	21.8	21.8	21.8	21.8	21.8	21.8
H21	14.6	14.6	14.6	19.3	24.0	26.1	26.4	26.4	26.4	26.4	26.4	26.4
H22	13.8	13.8	13.8	18.6	23.3	25.4	25.6	25.6	25.6	25.6	25.6	25.6
H23	10.6	10.6	10.6	15.3	20.0	22.1	22.4	22.4	22.4	22.4	22.4	22.4
H24	10.0	10.0	10.0	14.7	19.4	21.5	21.8	21.8	21.8	21.8	21.8	21.8
H26	7.9	7.9	7.9	12.6	17.4	19.5	19.7	19.7	19.7	19.7	19.7	19.7

House ID	Reference Wind Speed, Standardised v_{10} (ms^{-1})											
	1	2	3	4	5	6	7	8	9	10	11	12
H27	8.0	8.0	8.0	12.7	17.4	19.5	19.8	19.8	19.8	19.8	19.8	19.8
H28	11.1	11.1	11.1	15.8	20.5	22.6	22.9	22.9	22.9	22.9	22.9	22.9
H29	9.5	9.5	9.5	14.2	19.0	21.1	21.3	21.3	21.3	21.3	21.3	21.3
H30	9.1	9.1	9.1	13.9	18.6	20.7	20.9	20.9	20.9	20.9	20.9	20.9

11.7.5 Noise levels from the Proposed Development at all nearest residential properties are below 35dB(A), indicating that the noise immission levels would be regarded as acceptable and the resident's amenity as receiving 'sufficient protection' without further assessment requiring to be undertaken.

Predictions of Cumulative Noise Levels at Residential Properties

11.7.6 Cumulative noise impact from nearby wind farms that are operational, consented or in planning, and that are within the study area defined in accordance with the IoA GPG have been considered.

11.7.7 An assessment of the cumulative acoustic impact of the Proposed Development in conjunction with the operational Deucheran Wind Farm[16] and the proposed Clachaig Glen Wind Farm[15] has been undertaken in accordance with the guidance on wind farm noise assessment; ETSU-R 97 and the IoA GPG.

Deucheran Wind Farm

11.7.8 The planning application for the existing Deucheran Wind Farm was submitted in 1999. Predicted noise levels for the installed turbine type have been used in this assessment. A comparison between the resulting predicted noise levels, which are below 25 dB(A) at all considered properties, and the noise limits specified in the Decision Notice indicates that there is predicted to be significant headroom such that scaling the predicted noise levels to the conditioned limits would be unrealistic.

11.7.9 The turbine installed at Deucheran Wind Farm is the Vestas V66-1.75MW turbine. Warranted acoustic data for this turbine is taken from the manufacturer's general specification for this machine and

16 "Deucheran Wind Farm", Planning Reference Ref. 99/00925/DET, Argyll & Bute Council, 22 May 2001.

an uncertainty of 2 dB has been included[17]. Details used in this analysis are as follows:

- a hub height of 60m for all turbines. This is conservative, as in reality seven turbines have hub height of 46m;
- a rotor diameter of 66m;
- sound power levels, L_{WA}, for standardised 10m height wind speeds (v_{10}) as shown in **Table 11.17**; and
- octave band sound power level data, at the wind speeds where it is available, as shown in **Table 11.18**.

Table 11.17: A-Weighted Sound Power Levels (dB(A) re 1 pW) for the Vestas V66-1.75MW Wind Turbine

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	Sound Power Level (dBA)	Sound Power Level including uncertainty, (dBA)
1	101.0	103.0
2	101.0	103.0
3	101.0	103.0
4	101.0	103.0
5	101.0	103.0
6	101.0	103.0
7	104.9	106.9
8	106.2	108.2
9	106.7	108.7
10	106.8	108.8
11	106.8	108.8
12	106.8	108.8

17 "General Specification, Vestas V66-1.75MW, OptiSpeed – Wind Turbine", Item no. 944756, 17 April 2001

Table 11.18: Octave Band A-Weighted Sound Power Levels (dB(A) re 1 pW) at 10m Standardised Wind Speeds for the Vestas V66-1.75MW Wind Turbine

Octave Band (Hz)	8ms^{-1}
63	35.0
125	41.7
250	46.1
500	49.4
1000	49.4
2000	47.3
4000	44.2
OVERALL	106.2

Clachaig Glen Wind Farm

11.7.10 The acoustic emission data presented in the Clachaig Glen IA Report[15] are used to calculate the predicted noise levels from the proposed Clachaig Glen Wind Farm. A section 36 application for the proposed Clachaig Glen Wind Farm was submitted in 2022. Predicted noise levels for the turbine type proposed in the section 36 application have been used in this assessment.

11.7.11 The candidate turbine to be installed at the proposed Clachaig Glen Wind Farm is the Siemens Gamesa 5.0-145 turbine. Warranted acoustic data for this turbine is taken from the manufacturer's general specification for this machine and an uncertainty of 2 dB has been included. Details used in this analysis are as follows:

- a hub height of 132m for all turbines. This is conservative, as in reality seven turbines have hub height of 112 m;
- a rotor diameter of 145 m;
- sound power levels, L_{WA}, for standardised 10 m height wind speeds (v_{10}) as shown in **Table 11.19**; and
- octave band sound power level data, at the wind speeds where it is available, as shown in **Table 11.20** (including +2 dB uncertainty).

Table 11.19: A-Weighted Sound Power Levels (dB(A) re 1 pW) for the Siemens Gamesa 5.0-145 Wind Turbine at 132m hub height

Standardised 10m Height Wind Speed, v_{10} (ms^{-1})	Sound Power Level (dBA)	Sound Power Level including uncertainty, (dBA)
1	95.3	97.3
2	95.3	97.3
3	95.3	97.3
4	99.5	101.5
5	104.5	106.5
6	108.9	110.8
7	109.3	111.3
8	109.3	111.3
9	109.3	111.3
10	109.3	111.3
11	109.3	111.3
12	109.3	111.3

Table 11.20: Octave Band A-Weighted Sound Power Levels (dB(A) re 1 pW) at 10m Standardised Wind Speeds for the Siemens Gamesa 5.0-145 Wind Turbine at 132 m Hub Height

Octave Band (Hz)	$3ms^{-1}$	$4ms^{-1}$	$5ms^{-1}$	$6ms^{-1}$	$\geq 7ms^{-1}$
63	79.8	84	89	93.3	93.8
125	85.4	89.6	94.6	98.9	99.4
250	88.9	93.1	98.1	102.4	102.9
500	89.9	94.1	99.1	103.4	103.9
1000	91.7	95.9	100.9	105.2	105.7
2000	91.3	95.5	100.5	104.8	105.3
4000	85.1	89.3	94.3	98.6	99.1
8000	71.6	75.8	80.8	85.1	85.6

11.7.12 **Table 11.21** shows the maximum predicted operational noise levels resulting from the introduction of the Proposed Development operating cumulatively with the existing Deucheran Wind Farm and proposed Clachaig Glen Wind Farm, over a range of standardised 10 m height wind speeds, assuming downwind propagation at the nearest residential properties and using the prediction methodology and assumptions detailed at **Section 11.4**.

Table 11.21: Cumulative Predicted Operational Noise Levels, dB L_{A90}

House ID	Standardised 10 m height Wind Speed, ms^{-1}									
	3	4	5	6	7	8	9	10	11	12
H1	19.3	19.3	19.3	22.7	27.3	29.5	29.7	29.8	29.8	29.8
H2	21.4	21.4	21.4	25.0	29.5	31.6	31.9	32.0	32.0	32.0
H3	16.0	16.0	16.0	18.5	22.3	24.3	24.9	25.1	25.2	25.3
H4	17.1	17.1	17.1	19.7	23.5	25.5	26.1	26.3	26.4	26.5
H5	17.5	17.5	17.5	20.3	24.2	26.2	26.8	27.0	27.1	27.1
H6	18.6	18.6	18.6	21.9	26.1	28.2	28.6	28.7	28.8	28.8
H7	19.3	19.3	19.3	22.7	27.2	29.4	29.6	29.7	29.8	29.8
H8	16.9	16.9	16.9	19.3	23.0	25.0	25.6	25.9	26.0	26.1
H9	17.3	17.3	17.3	19.9	23.8	25.7	26.3	26.6	26.7	26.7
H10	18.3	18.3	18.3	21.5	25.7	27.8	28.2	28.3	28.4	28.4
H11	15.8	15.8	15.8	18.3	22.1	24.0	24.7	24.9	25.1	25.1
H12	19.4	19.4	19.4	22.5	26.7	28.8	29.2	29.3	29.4	29.4
H13	18.8	18.8	18.8	22.4	27.1	29.3	29.4	29.5	29.5	29.5
H14	20.5	20.5	20.5	23.9	28.2	30.3	30.7	30.8	30.8	30.9
H15	20.7	20.7	20.7	24.2	28.8	30.9	31.2	31.2	31.3	31.3
H16	20.6	20.6	20.6	24.3	29.0	31.3	31.4	31.4	31.4	31.4
H17	19.3	19.3	19.3	22.5	26.7	28.7	29.2	29.3	29.4	29.4
H18	20.6	20.6	20.6	24.2	28.8	30.9	31.2	31.2	31.3	31.3
H19	17.1	17.1	17.1	19.7	23.5	25.5	26.1	26.3	26.4	26.5
H20	16.0	16.0	16.0	18.5	22.3	24.3	24.9	25.1	25.2	25.3
H21	20.0	20.0	20.0	23.6	28.2	30.3	30.6	30.6	30.7	30.7
H22	18.5	18.5	18.5	21.6	25.8	27.9	28.3	28.5	28.5	28.6
H23	16.1	16.1	16.1	18.7	22.6	24.6	25.2	25.4	25.5	25.5
H24	18.9	18.9	18.9	22.5	27.2	29.5	29.6	29.6	29.7	29.7
H26	20.6	20.6	20.6	24.2	29.1	31.3	31.4	31.4	31.5	31.5
H27	19.3	19.3	19.3	23.0	27.8	30.0	30.1	30.2	30.2	30.2
H28	25.6	25.6	25.6	29.3	34.2	36.5	36.5	36.5	36.5	36.6
H29	20.9	20.9	20.9	24.6	29.4	31.7	31.8	31.8	31.8	31.8
H30	19.7	19.7	19.7	23.4	28.3	30.5	30.6	30.6	30.6	30.6

11.7.13 The predicted cumulative turbine noise levels do not exceed 35 dB(A) for all wind speeds at all of the properties with the exception of H28 High Clachaig.

11.7.14 As shown in **Table 11.16**, the predicted noise levels associated with the operation of the Proposed Development at H28 will be 22.9 dB(A), which is at least 10 dB lower than that associated with

existing / proposed levels and can be considered insignificant as a result.

11.7.15 **Table 11.22** and **Table 11.23** show respectively the daytime and night-time margins by which the predicted operational noise levels resulting from combined operation of the Proposed Development with the existing Deucheran Wind Farm and proposed Clachaig Glen Wind Farm meets the noise limits set out in **Table 11.12** and **Table 11.13** for daytime and night-time respectively. A negative number shows that predicted levels are below the relevant noise limits at each residence.

Table 11.22: Cumulative Daytime Predicted Margin of Compliance, dB

House ID	Standardised 10 m height Wind Speed, $m.s^{-1}$									
	3	4	5	6	7	8	9	10	11	12
H1	-15.7	-12.3	-7.7	-6.6	-8.0	-9.7	-12.1	-14.9	-18.5	-22.8
H2	-18.0	-18.8	-16.2	-14.5	-13.8	-13.2	-13.3	-14.7	-18.4	-24.9
H3	-19.0	-16.5	-12.7	-10.7	-10.1	-9.9	-9.8	-9.7	-9.7	-9.7
H4	-17.9	-15.3	-11.5	-9.5	-8.9	-8.7	-8.6	-8.5	-8.5	-8.5
H5	-17.5	-14.7	-10.8	-8.8	-8.2	-8.0	-7.9	-7.9	-7.9	-7.9
H6	-16.4	-13.1	-9.2	-8.7	-10.1	-12.0	-14.2	-16.9	-20.0	-23.8
H7	-15.7	-12.3	-7.8	-5.6	-5.4	-5.3	-5.2	-5.2	-5.2	-5.2
H8	-18.1	-15.7	-12.0	-10.0	-9.4	-9.1	-9.0	-8.9	-8.9	-8.9
H9	-17.7	-15.1	-11.2	-9.3	-8.7	-8.4	-8.3	-8.3	-8.3	-8.3
H10	-16.7	-13.5	-9.3	-7.2	-6.8	-6.7	-6.6	-6.6	-6.6	-6.6
H11	-19.2	-16.7	-12.9	-11.0	-10.3	-10.1	-9.9	-9.9	-9.9	-9.9
H12	-15.6	-12.5	-8.3	-6.2	-5.8	-5.7	-5.6	-5.6	-5.6	-5.6
H13	-16.2	-12.6	-7.9	-5.7	-5.6	-5.5	-5.5	-5.5	-5.5	-5.5
H14	-14.5	-11.1	-7.1	-6.6	-8.0	-9.9	-12.2	-14.8	-17.9	-21.7
H15	-14.3	-10.8	-6.2	-5.2	-6.5	-8.3	-10.6	-13.4	-17.0	-21.3
H16	-18.8	-19.5	-16.7	-14.8	-14.3	-13.8	-13.9	-15.3	-19.0	-25.5
H17	-15.7	-12.5	-8.3	-6.3	-5.8	-5.7	-5.6	-5.6	-5.6	-5.6
H18	-14.4	-10.8	-6.2	-4.1	-3.8	-3.8	-3.7	-3.7	-3.7	-3.7
H19	-17.9	-15.3	-11.8	-11.4	-12.6	-14.4	-16.6	-19.2	-22.3	-26.1
H20	-19.0	-16.5	-12.7	-10.7	-10.1	-9.9	-9.8	-9.7	-9.7	-9.7
H21	-15.0	-11.4	-6.8	-4.7	-4.4	-4.4	-4.3	-4.3	-4.3	-4.3
H22	-16.5	-13.4	-9.2	-7.1	-6.7	-6.5	-6.5	-6.4	-6.4	-6.4
H23	-18.9	-16.3	-12.4	-10.4	-9.8	-9.6	-9.5	-9.5	-9.5	-9.5
H24	-16.1	-12.5	-7.8	-5.5	-5.4	-5.4	-5.3	-5.3	-5.3	-5.3
H26	-14.6	-15.3	-12.8	-11.7	-12.0	-12.1	-12.6	-14.1	-17.2	-22.5
H27	-15.7	-12.0	-7.2	-5.0	-4.9	-4.8	-4.8	-4.8	-4.8	-4.8
H28	-9.4	-5.7	**-2.6**	-2.9	-4.9	-6.7	-8.5	-10.7	-13.7	-17.8

House ID	Standardised 10 m height Wind Speed, m.s^{-1}									
	3	4	5	6	7	8	9	10	11	12
H29	-14.1	-12.1	-11.0	-11.3	-13.3	-15.0	-16.8	-19.0	-21.9	-25.9
H30	-15.3	-11.6	-8.5	-8.9	-10.8	-12.6	-14.4	-16.7	-19.7	-23.8

Table 11.23: Cumulative Night-time Predicted Margin of Compliance, dB

House ID	Standardised 10 m height Wind Speed, m.s^{-1}									
	3	4	5	6	7	8	9	10	11	12
H1	-23.7	-20.3	-15.7	-13.5	-13.3	-13.2	-14.5	-17.4	-20.6	-20.6
H2	-23.6	-19.8	-15.2	-13.3	-13.4	-13.9	-14.9	-16.3	-18.1	-20.3
H3	-27.0	-24.5	-20.7	-18.7	-18.1	-17.9	-17.8	-17.7	-17.7	-17.7
H4	-25.9	-23.3	-19.5	-17.5	-16.9	-16.7	-16.6	-16.5	-16.5	-16.5
H5	-25.5	-22.7	-18.8	-16.8	-16.2	-16.0	-15.9	-15.9	-15.9	-15.9
H6	-24.4	-21.1	-16.9	-14.8	-14.4	-14.3	-15.1	-18.1	-21.7	-21.7
H7	-23.7	-20.3	-15.8	-13.6	-13.4	-13.3	-13.2	-13.2	-13.2	-13.2
H8	-26.1	-23.7	-20.0	-18.0	-17.4	-17.1	-17.0	-16.9	-16.9	-16.9
H9	-25.7	-23.1	-19.2	-17.3	-16.7	-16.4	-16.3	-16.3	-16.3	-16.3
H10	-24.7	-21.5	-17.3	-15.2	-14.8	-14.7	-14.6	-14.6	-14.6	-14.6
H11	-27.2	-24.7	-20.9	-19.0	-18.3	-18.1	-17.9	-17.9	-17.9	-17.9
H12	-23.6	-20.5	-16.3	-14.2	-13.8	-13.7	-13.6	-13.6	-13.6	-13.6
H13	-24.2	-20.6	-15.9	-13.7	-13.6	-13.5	-13.5	-13.5	-13.5	-13.5
H14	-22.5	-19.1	-14.8	-12.7	-12.3	-12.2	-13.1	-16.0	-19.6	-19.6
H15	-22.3	-18.8	-14.2	-12.1	-11.8	-11.8	-13.0	-15.9	-19.1	-19.1
H16	-24.4	-20.5	-15.7	-13.6	-13.9	-14.5	-15.5	-16.9	-18.7	-20.9
H17	-23.7	-20.5	-16.3	-14.3	-13.8	-13.7	-13.6	-13.6	-13.6	-13.6
H18	-22.4	-18.8	-14.2	-12.1	-11.8	-11.8	-11.7	-11.7	-11.7	-11.7
H19	-25.9	-23.3	-19.5	-17.5	-16.9	-16.7	-17.5	-20.4	-24.0	-24.0
H20	-27.0	-24.5	-20.7	-18.7	-18.1	-17.9	-17.8	-17.7	-17.7	-17.7
H21	-23.0	-19.4	-14.8	-12.7	-12.4	-12.4	-12.3	-12.3	-12.3	-12.3
H22	-24.5	-21.4	-17.2	-15.1	-14.7	-14.5	-14.5	-14.4	-14.4	-14.4
H23	-26.9	-24.3	-20.4	-18.4	-17.8	-17.6	-17.5	-17.5	-17.5	-17.5
H24	-24.1	-20.5	-15.8	-13.5	-13.4	-13.4	-13.3	-13.3	-13.3	-13.3
H26	-22.4	-18.8	-13.9	-12.2	-12.3	-12.3	-12.5	-13.6	-16.2	-20.8
H27	-23.7	-20.0	-15.2	-13.0	-12.9	-12.8	-12.8	-12.8	-12.8	-12.8
H28	-17.4	-13.7	-8.8	-6.5	-6.5	-6.9	-7.9	-9.6	-12.5	-17.2
H29	-22.1	-18.4	-13.6	-12.8	-13.8	-14.8	-16.0	-18.0	-21.4	-26.6
H30	-23.3	-19.6	-14.7	-12.5	-12.4	-12.8	-13.8	-15.6	-18.5	-23.2

11.7.16 Cumulative noise levels at all residential properties are within both the daytime and night-time noise limits at all wind speeds considered. The minimum margin of predicted noise levels below derived noise limits during daytime periods is -2.6 dB(A) at H28 High

Clachaig. Similarly, the minimum margin during night-time periods is -6.5 dB(A) at H28 also at H28 High Clachaig.

11.7.17 At the residential property with the smallest margin to the limits, High Clachaig, the predicted noise levels due to all cumulative wind farms, and noise limits, are shown graphically in Chart 11.5.7 & Chart 11.5.8 in **Technical Appendix 11.5.**

11.7.18 The assessment shows that predicted cumulative/combined noise levels meet the limiting requirements of ETSU-R-97 at all properties. Therefore, the operational noise levels resulting from the operation of the Proposed Development in combination with the existing Deucheran Wind Farm and proposed Clachaig Glen Wind Farm developments are considered **not significant**.

Construction and Decommissioning Effects

11.7.19 Primary activities creating noise during the construction period include the construction of the wind turbine bases, the erection of the wind turbines, the excavation of trenches for cables, and the construction of associated hardstands, access tracks and compounds. Noise from vehicles on public roads and access tracks would also arise due to the delivery of wind turbine components and construction materials, notably aggregates, concrete and steel reinforcement.

11.7.20 The exact methodology and timing of construction activities have not yet been defined and a reliable assessment of expected construction noise levels is not possible as a result. However, as discussed in **Section 11.4**, works expected to be undertaken at or around the proposed wind turbine locations would occur at distances that are unlikely result in noise levels that would breach typical criteria at neighbouring residential properties in this regard.

11.7.21 The access route for the Proposed Development is expected to pass reasonably close to some residential properties and with some upgrade works to existing access tracks and public roads also expected to occur in close proximity to these residential properties. In these instances, the level of noise generated by construction works could be close to the limits defined as part of the 'ABC method' discussed earlier. As a result, typical construction noise mitigation

measures are provided in **Section 11.8** which aim to minimise noise as far as reasonably practicable and/or reasonable.

11.7.22 The movement of additional vehicles, including heavy goods vehicles (HGVs), along public roads and access routes may well be noticeable to residents adjacent to these in terms of the noise and vibration generated by them. The resultant impacts on public roads, that are already well used by local traffic and existing HGV movements, would be relatively minor in terms of the increase in average noise levels resulting from the additional vehicles on the public roads. However, the individual events may well be noticeable to residents, with resulting levels for individual events being similar to that created by existing HGV movements. The resultant noise levels on parts of the route that are less well used by existing traffic would be noticeable to residents located along the route. However, the resultant noise and vibration levels from vehicles passing the dwellings would be unlikely to breach the adopted construction noise limits and accepted vibration thresholds.

11.7.23 The noise associated with blasting at 'borrow pit' locations may well be audible to neighbouring residents. However, the level of noise, overpressure and vibration generated by each blast would be well below levels that would be expected to cause damage to the nearest housing and/or structures. **Section 11.8** provides details as to standard mitigation measures to be incorporated into the blasting processes and may also be included within the CEMP.

11.8 Mitigation

Operational Noise

11.8.1 One of the key constraints and considerations in designing the layout of the wind turbines was the minimisation of potential noise impacts at the nearest residential receptors. As such the wind turbine layout was designed to ensure that there is an adequate separation distance between any of the proposed turbines and the nearest residential property.

11.8.2 Due to this consideration of the noise impacts in the design of the Proposed Development, by embedding mitigation measures in the

wind turbine layout, when a conservative candidate machine is modelled this meets the noise limits are derived in accordance with ETSU-R-97.

11.8.3 If planning permission is granted for the Proposed Development, planning conditions can be proposed to provide a degree of protection to nearby residents in the form of limits relating to noise level and tonality.

11.8.4 **Technical Appendix 11.6** contains a set of draft planning conditions relating to noise that the Applicant considers appropriate.

Construction and Decommissioning Noise

11.8.5 For all activities, measures would be taken to reduce noise levels with due regard to practicality and cost as per the concept of 'best practicable means' as defined in Section 72 of the Control of Pollution Act 1974.

11.8.6 BS 5228-1:2009 states that the 'attitude of the contractor' is important in minimising the likelihood of complaints and therefore consultation with the local authority is recommended along with steps to inform residents of intended activity. Non-acoustic factors, which influence the overall level of complaints such as mud on public roads and dust generation, would also be controlled through construction practices adopted on-site and managed via a Construction and Environmental Management Plan (CEMP).

11.8.7 Furthermore, the following noise mitigation options could be implemented where appropriate:

- Consideration would be given to noise emissions when selecting plant and equipment to be used on-site;
- All equipment should be maintained in good working order and fitted with the appropriate silencers, mufflers or acoustic covers where applicable;
- Stationary noise sources would be sited as far away as reasonably possible from residential properties and where necessary and appropriate, acoustic barriers could be used to screen them;
- The movement of vehicles to and from the Proposed Development would be controlled and employees instructed to

ensure compliance with the noise control measures adopted; and

- Site operations would be limited to 07:00-19:00 Monday to Friday and 07:00 – 13:00 on Saturdays, except during wind turbine /erection and commissioning or during periods of emergency work.

11.8.8 There are many strategies to reduce construction noise by the limitation of activities that would result in predicted noise levels being lower than the specified targets. Any such measures should be considered adequate, and the mitigation adopted should not be limited to the proposed measures.

11.8.9 With specific regard to blasting, it is proposed that the following mitigation measures are implemented:

- Good practice on blasting, as recommended by Planning Advice Note (PAN) 50 'Controlling the environmental effects of surface mineral workings'[18] shall be followed;
- The vibration and air overpressure reduction methods outlined in Section 8.6.9.2 of BS 5228-2:2009 shall be adhered to where appropriate;
- Advance warning shall be given to nearby residents;
- Blasting should only occur between the hours of 08:00-18:00 on Mondays-Fridays or between the hours of 08:00-13:00 on Saturdays; and
- No more than three blasts per day should occur.

11.8.10 Depending upon the charge sizes required it may be prudent to perform trial blasts with smaller amounts of explosive and measure vibration magnitudes at various distances to more accurately determine how vibration propagates at the Proposed Development.

11.8.11 As with operational noise, if planning permission is granted for the proposed wind farm, planning conditions can be proposed so that appropriate noise mitigation measures and construction practices are included within a CEMP.

[18] 'Planning Advice Note 50: Controlling the environmental effects of surface mineral workings', Scottish Government, October 1996. Available at: https://www.gov.scot/publications/planning-advice-note-pan-50-controlling-environmental-effects-surface-mineral/

11.9 Assessment of Residual Effects

Operational

11.9.1 The acoustic assessment demonstrates that predicted noise levels at residential properties do not exceed the derived noise limits. This should not be interpreted to mean that wind farm operational noise would be inaudible (or masked by background noise) under all conditions, but that the levels of noise are acceptable under ETSU-R-97 and associated guidance.

Construction

11.9.2 Noise and vibration during the construction and decommissioning of the Proposed Development may well be audible and/or perceptible to people residing in the area, but the levels would be below established noise limits and planning requirements in this respect due to the large distances between the site and the surrounding residential properties. Where construction noise relating to the provision of access to the site, including the upgrade of public roads and their use thereof, is expected to occur in close proximity to residential properties, enhanced mitigation measures would be adopted to reduce noise and vibration where necessary. The impacts resulting from blasting at borrow pits are only considered in terms of the steps to limit any resulting impact through appropriate blast design and best practice, which also involves keeping residents informed as to planned blasting activities, with no significant impacts being expected.

11.10 Summary

11.10.1 The acoustic impact for the operation of the Proposed Development on nearby residential properties has been assessed in accordance with the guidance on wind farm noise as issued in the DTI publication 'The Assessment and Rating of Noise from Wind Farms', otherwise known as ETSU-R-97, and Institute of Acoustics Good Practice Guide (IoA GPG), as recommended for use by relevant planning policy.

11.10.2 To establish baseline conditions, background sound surveys were carried out at two nearby properties and the measured background sound levels used to determine appropriate noise limits, as specified by ETSU-R-97 and the IoA GPG. The results of four further sound surveys were included within this assessment which were conducted in support of the planning application for Clachaig Glen Wind Farm.

11.10.3 Operational noise levels were predicted using the recommended noise propagation model. The predicted noise levels for the Proposed Development are within the derived noise limits at all considered wind speeds. The Proposed Development therefore complies with the relevant guidance on wind farm noise and the impact on the amenity of all nearby residential properties would be regarded as acceptable.

11.10.4 Construction noise has been discussed with reference to BS 5228 and it has been determined that on-site construction noise levels are highly unlikely to exceed typical limiting noise criteria at nearby residential properties although appropriate mitigation measures will be adopted as a matter of due course. The access route for the Proposed Development is expected to pass reasonably close to residential properties and with some upgrade works to existing access tracks and public roads potentially occurring in close proximity to some of these residential properties. In these instances, the level of noise generated by construction works could be close to typical limits for relatively brief periods. As a result, typical and enhanced construction noise mitigation measures are provided within the chapter which aim to minimise noise as far as reasonably practicable and/or reasonable.

11.10.5 Vibration and air overpressure due to blasting are not expected to have a significant impact on nearby residents should the mitigation measures described within the chapter be adopted.

11.10.6 The potential impact of the Proposed Development, along with the mitigation proposed and any residual effect, is summarised in **Table 11.24.**

Table 11.24: Summary of Potential Impacts, Mitigation and Residual Effects

Potential Impact	Mitigation Proposed	Means of Implementation	Outcome/ Residual Effect
Operation			
Potential impact on residential amenity due to operational noise	The Proposed Development operating in isolation and cumulatively with other existing operational and proposed wind farm developments meet the limiting requirements of ETSU-R-97. As a result, no mitigation is required.	Not applicable	Not significant
Construction and Decommissioning			
Potential for noise and vibration to be created during general construction activities and by construction traffic	Due regard for 'best practicable means' (defined by Section 72 of the Control of Pollution Act 1974). A range of noise mitigation measures are proposed for the construction phase in accordance with measures outlined in BS 5228-1:2009. Site operations to be limited to 07:00 – 19:00 Mondays to Fridays, and 07:00-13:00 on Saturdays (except during wind turbine delivery/erection and commissioning/periods of emergency work). Good practice on blasting shall be followed along with guidance on blast frequency and timing.	Noise mitigation measures would be implemented as part of the CEMP which would be required to be agreed as a condition of consent.	Not significant

Glossary

Word	Definition
A-weighting	A frequency-response function providing good correlation with the sensitivity of the human ear.
Broadband Noise	Noise which covers a wide range of frequencies (see Frequency).
Decibel dB(A)	The decibel (dB) is a logarithmic unit used in acoustics to quantify sound levels relative to a 0dB reference (e.g. a sound pressure level of $2*10^{-5}$ Pa). The 'A' signifies A-weighting.
Equivalent Continuous Sound Level (L_{eq})	The equivalent continuous sound level is a notional steady noise level, which over a given time would provide the same energy as the intermittent noise.
Frequency	Refers to how quickly the air vibrates, or how close the sound waves are to each other and is measured in cycles per second, or Hertz (Hz). The lowest frequency audible to humans is 20Hz and the highest is 20,000Hz. The human ear is most sensitive to the 1kHz, 2kHz and 4kHz octave bands and much less sensitive at lower audible frequencies.
Frequency Spectrum	Description of the sound pressure level of a source as a function of frequency.
Percentile Sound Level (L_{90})	Sound pressure level exceeded for 90% of the time for any given time interval. For example, $L_{(A)90,10min}$ means the A-weighted level that is exceeded for 90% of a ten-minute interval. This indicates the noise levels during quieter periods, or the background noise level. It represents the lower estimate of the prevailing noise level and is useful for excluding such effects as aircraft or dogs barking on background noise levels.
Noise Emission	The noise energy emitted by a source (e.g. a wind turbine).
Noise Immission	The sound pressure level detected at a given location (e.g. nearest dwelling).
Octave Band	Range of frequencies between one frequency ($f_0*2^{-1/2}$) and a second frequency ($f_0*2^{+1/2}$). The quoted centre frequency of the octave band is f_0.
Sound Power Level	Sound power level is the acoustic power radiated from a sound source and is independent of the surroundings. It is a logarithmic measure in comparison to a reference level (10^{-12} watts).
Sound Pressure Level	A logarithmic measure of the effective sound pressure of a sound relative to a reference value which is for minimum audible field conditions ($20*10^{-6}$Pa).
Third Octave Band	The range of frequencies between one frequency ($f_0*2^{-1/6}$) and a second frequency equal to ($f_0*2^{+1/6}$). The quoted centre frequency of the third octave band is f_0.

Word	Definition
Tonal Noise	A noise that contains a noticeable or discrete, continuous note and includes noises such as hums, hisses, screeches.