10 NOISE

10.1 INTRODUCTION

This Chapter of the Environmental Impact Assessment Report (EIA Report) evaluates the effects of the Ackron Wind Farm (the Development) on the acoustic environment of the area around the Development. This assessment was undertaken by Arcus Consultancy Services Limited (Arcus).

This Chapter includes the following elements:

- Legislation, Policy and Guidance;
- Assessment Methodology and Significance Criteria;
- Baseline Conditions;
- Assessment of Potential Effects;
- Mitigation and Residual Effects;
- Cumulative Effect Assessment;
- Summary of Effects;
- Statement of Significance; and
- Glossary.

The following terms are used within this Chapter to describe the Development and various associated study areas:

- The Development: the whole physical process involved in the development of Ackron Wind Farm, including wind farm construction, operation and decommissioning (i.e. not a piece of land or an area);
- The Site Boundary: the red line or application boundary as shown in Figure 1.2;
- The Site: the land within the Site Boundary available for turbine development and associated wind farm infrastructure; and
- Cumulative Assessment Study Area: the area defined by the green and orange shading within the purple 35 decibel (dB(A)) contour line shown in Figure 10.1.

This Chapter of the EIA Report is supported by the following figures provided in Volume 2 Figures excluding Landscape and Visual:

- Figure 10.1: Cumulative Noise Contour Plot.

This Chapter has been written by Michael Reid, Senior Acoustics Consultant at Arcus, who is a Full Member of the Institute of Acoustics (MIOA) and reviewed by Heather Kwiatkowski, Principal EIA Consultant at Arcus, and Stuart Davidson, Registered EIA Practitioner and Operational Director at Arcus.

10.2 LEGISLATION, POLICY AND GUIDANCE

10.2.1 Legislation

The following legislation documents are of particular relevance to the assessment:

- The Control of Pollution Act 1974 (CoPA 1974)[1]; and
- The Environmental Protection Act 1990[2] (EPA 1990).

[1] UK Government (1974). The Control of Pollution Act 1974. Available at: http://www.legislation.gov.uk/ukpga/1974/40 (Accessed 06/08/2020)
[2] UK Government (1990). The Environmental Protection Act 1990. Available at: http://www.legislation.gov.uk/ukpga/1990/43/contents (Accessed 06/08/2020)

10.2.1.1 The Control of Pollution Act 1974

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

Section 60 of the CoPA 1974 enables a Local Authority to serve a notice to persons carrying out construction work of its requirements for the control of site noise. This may specify plant or machinery that is or is not to be used; the hours during which construction work may be carried out; the level of noise or vibration that may be emitted; and provide for changes in circumstances. Appeal procedures are available.

Section 61 of the CoPA 1974 allows for those carrying out construction work to apply to the Local Authority in advance for consent to carry out the works. This is not mandatory, but is often advantageous for the developer, as once consent is issued, the Local Authority is no longer able to take action under Section 60 of CoPA 1974 or Section 80 of the EPA 1990, provided the works are carried out in accordance with the Section 61 consent. It does not, however, prevent nuisance action under Section 82 of the EPA 1990. The Application is expected to give as much detail as possible about the works to be carried out, the methods to be used, and the measures that will be taken to minimise noise and vibration.

10.2.1.2 The Environmental Protection Act 1990

The EPA 1990 specifies mandatory powers available to Local Authorities in respect of any noise that either constitutes or is likely to cause a statutory nuisance, which is also defined in the CoPA 1974. A duty is imposed on Local Authorities to carry out inspections to identify statutory nuisances, and to serve abatement notices against these. Procedures are also specified with regards to complaints from persons affected by a statutory nuisance.

10.2.2 Policy and Guidance

The following key policy and guidance has been considered in carrying out this assessment.

10.2.2.1 Local Development Plan Policy and Supplementary Guidance

Chapter 2: Energy and Planning Policy of this EIA Report summarises all local planning policies applicable to the Development.

10.2.2.2 Construction Noise

Guidance relevant to the effects of noise and vibration during construction and decommissioning is provided by BS 5228[3]. This standard:

- Is published in two parts: Part 1 - Noise and Part 2 - Vibration. The discussion below relates mainly to Part 1, however, the recommendations of Part 2 in terms of vibration are broadly very similar;
- Refers to the need for the protection against noise and vibration of persons living and working in the vicinity of, and those working on construction and open sites;
- Recommends procedures for noise and vibration control in respect of construction operations;
- Stresses the importance of community relations, and states that early establishment and maintenance of these relations throughout site operations will go some way towards allaying people's concerns;
- Provides recommendations regarding the supervision, planning, preparation and execution of works, emphasising the need to consider noise at every stage of the operation;

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

- Describes methods of controlling noise at source and its spread; and
- Includes a discussion of noise control targets, and example criteria for the assessment of the significance of noise effects.

10.2.2.3 Operational Noise

Guidance relevant to the effects of noise during operation is provided in the following guidance and information sources:

- The Scottish Government's web-based planning information on onshore wind turbines[4];
- Planning Advice Note 1/2011 (PAN 1/2011): Planning and Noise[5];
- ETSU-R-97: The Assessment and Rating of Noise from Wind Farms[6]; and
- A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise[7].

The Scottish Government's web-based Planning Information on Onshore Wind Turbines and PAN 1/2011

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

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

PAN 1/2011 promotes the principles of good acoustic design and the appropriate location of new potentially noisy development. The associated Technical Advice Note offers advice on the assessment of noise impact and includes details of the legislation, technical standards and codes of practice appropriate to specific noise issues. Appendix 1 of the Technical Advice Note: Assessment of Noise describes the use of ETSU-R-97 in the assessment of wind turbine noise.

ETSU-R-97

ETSU-R-97 provides a framework for the assessment and rating of noise from wind turbine installations. It is the de facto standard for wind farm developments in the UK, and the methodology has therefore been adopted for the present assessment as agreed via scoping (see Technical Appendices A5.1 – A5.4).

Both background noise and noise from wind turbines typically vary with wind speed. According to ETSU-R-97, wind farm noise assessments should therefore consider the site-specific relationship between wind speed and background noise, along with the particular noise emission characteristics of the proposed wind turbines.

ETSU-R-97 specifies the use of the $L_{A90,10min}$ descriptor for both background and wind turbine noise. Therefore, unless otherwise specified, all references to noise levels within this Chapter relate to this descriptor. Similarly, all wind speeds referred to relate to a

[4] Scottish Government (2014) Onshore Wind Turbines Planning Advice [Online] Available at: https://www.gov.scot/publications/onshore-wind-turbines-planning-advice/ (accessed 06/08/2020)
[5] The Scottish Government (2011) Planning Advice Note PAN 1/2011 Planning and Noise and accompanying Technical Advice Note, 2011
[6] ETSU 1996 ETSU-R-97 The Assessment and Rating of Noise from Wind Turbines, ETSU for the DTI, 1996
[7] A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind turbine Noise, IOA, 2013.

height of 10 metres (m) Above Ground Level (AGL) at the location of the Development, standardised in accordance with current good practice guidance.

The document recommends the application of external noise limits at the nearest noise sensitive properties, to protect outside amenity and prevent sleep disturbance inside dwellings. These limits take the form of a 5 dB margin above the prevailing background noise level, except where background noise levels are lower than certain thresholds, where fixed lower limits apply. Separate limits apply for quiet daytime and night-time periods, as outlined below. The limits apply to the cumulative effects of all wind turbines that affect a particular location.

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

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

ETSU-R-97 recommends that the fixed lower noise limit for daytime should be set within the range 35 to 40 dB, $L_{A90,10min}$, with choice of value dependent on the following factors:

i) The number of dwellings in the neighbourhood of the Development;
ii) The effect of the noise limits on the number of kilo Watt hours (kWh) generated; and
iii) The duration and level of exposure.

Different standards apply at night, where potential sleep disturbance is the primary concern rather than the requirement to protect outdoor amenity. Night-time is considered to be all periods between 23:00 and 07:00. A limit of 43 dB(A) is recommended at night at wind speeds or locations where the prevailing wind speed related night-time background noise level is lower than 38 dB(A). At other times, the limit of 5 dB above the prevailing wind speed-related background noise level applies. The value of night-time fixed lower limit was selected in order to ensure that internal noise levels remained below those considered to have the potential to cause sleep disturbance, taking account of the attenuation of noise when passing from outdoors to indoors, and making allowance for the presence of open windows.

Where the occupier of the property has a financial interest in the Development, ETSU-R-97 states that the fixed lower noise limit for both daytime and night-time can be increased to 45 dB(A) and that *"…consideration should be given to increasing the permissible margin above background".*

A 'simplified criterion' is also described which is applicable where there are large separation distances between the proposed turbines and nearest noise-sensitive receptors. In such cases, a fixed limit of 35 dB, $L_{A90,10min}$ applies, without reference to background noise levels.

The IOA Good Practice Guide

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

The GPG provides advice on the assessment of cumulative noise impact, detailing a number of possible cumulative scenarios and recommended approaches. Advice is also

provided with regard to the geographical scope of a cumulative noise assessment, to determine the area within which a cumulative noise assessment is necessary.

Where a new noise source is introduced to a given scenario with a noise level which is predicted to be 10 dB or more below the existing level, the increase in the total noise level is considered to be negligible. On this basis, the necessary extents of a cumulative noise assessment can be determined. Paragraph 5.1.4 of the GPG states:

"*If the proposed wind farm produces noise levels within 10 dB of any existing wind farm(s) at the same receptor location, then a cumulative noise impact assessment is necessary*".

As noted in ETSU-R-97, noise from existing wind turbines should not form part of the background noise level from which noise limits for new wind energy developments are derived.

10.2.2.4 Low-Frequency Noise and Infrasound Studies

A study[8], published in 2006 by acoustic consultants Hayes McKenzie on the behalf of the Department of Trade and Industry (DTI), investigated low frequency noise from wind farms. This study concluded that there is no evidence of health effects arising from infrasound or low frequency noise generated by wind turbines, but that complaints attributed to low frequency noise were in fact, possibly due to a phenomenon known as Amplitude Modulation (AM).

Further, in February 2013, the Environmental Protection Authority of South Australia published the results of a study into infrasound levels near wind farms[9]. This study measured infrasound levels at urban locations, rural locations with wind turbines close by, and rural locations with no wind turbines in the vicinity. It found that infrasound levels near wind farms are comparable to levels away from wind farms in both urban and rural locations. Infrasound levels were also measured during organised shut downs of the wind farms; the results showed that there was no noticeable difference in infrasound levels whether the turbines were active or inactive.

Bowdler et al. (2009)[10] concludes that:

"...there is no robust evidence that low frequency noise (including 'infrasound') or ground-borne vibration from wind farms generally has adverse effects on wind farm neighbours".

10.2.2.5 Research into Amplitude Modulation

A study[11] was carried out on behalf of the Department for Business, Enterprise and Regulatory Reform (BERR) by the University of Salford, which investigated the incidence of noise complaints associated with wind farms and whether these were associated with AM. This report defined AM as aerodynamic noise from wind turbines with a greater degree of fluctuation than normal at blade passing frequency. Its aims were to ascertain the prevalence of AM on UK wind farm sites, to try to gain a better understanding of the likely causes, and to establish whether further research into AM is required.

The study concluded that AM has occurred at only a small number of wind farms in the UK (4 of 133), and only for between 7% and 15% of the time. It also states that, at the

[8] The measurement of low frequency noise at three UK wind farms, Hayes Mckenzie, The Department for Trade and Industry, URN 06/1412, 2006.
[9] Environment Protection authority (2013) Infrasound levels near wind farms and in other environments [online] Available at: http://www.epa.sa.gov.au/xstd_files/Noise/Report/infrasound.pdf (accessed 06/08/2020)
[10] Bowdler et al. (2009). Prediction and Assessment of Wind Turbine Noise: Agreement about relevant factors for noise assessment from wind energy projects. Acoustic Bulletin, Vol 34 No2 March/April 2009, Institute of Acoustics
[11] Research into aerodynamic modulation of wind turbine noise'. Report by University of Salford, The Department for Business, Enterprise and Regulatory Reform, URN 07/1235, July 2007.

time of writing, the causes of AM were not well understood and that prediction of the effect was not currently possible.

This research was updated in 2013 by an in-depth study undertaken by Renewable UK[12], which identified that many of the previously suggested causes of AM have little or no association to the occurrence of AM in practice. The generation of AM is based upon the interaction of a number of factors, the combination and contributions of which are unique to each site. With the current knowledge, it is not possible to predict whether any particular site is more or less likely to give rise to AM, and the incidence of AM occurring at any particular site remains low, as identified in the University of Salford study.

In 2016, the IOA proposed a measurement technique[13] to quantify the level of AM present in any particular sample of wind farm noise. This technique is supported by the Department of Business, Energy & Industrial Strategy (BEIS, formerly The Department of Energy & Climate Change) who have published guidance[14], which follows on from the conclusions of the IOA study in order to define an appropriate assessment method for AM, including a penalty scheme and an outline planning condition. Notwithstanding this, the suggested outline planning condition is as yet unvalidated, remains in a draft form and would require site-specific legal advice on its appropriateness to a specific development.

Section 7.2.1 of the GPG therefore remains current, stating:

"The evidence in relation to 'Excess' or 'Other' Amplitude Modulation (AM) is still developing. At the time of writing, current practice is not to assign a planning condition to deal with AM".

It is therefore not considered necessary to carry out a specific assessment of AM.

10.2.2.6 Vibration

Research undertaken by Snow[15] found that levels of ground-borne vibration 100 m from the nearest wind turbine were significantly below criteria for 'critical working areas' given by British Standard BS 6472:1992 Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz), and were lower than limits specified for residential premises by an even greater margin.

Ground-borne vibration from wind turbines can be detected using sophisticated instruments several kilometres (km) from the wind farm site as reported by Keele University[16]. This report clearly shows that, although detectable using highly sensitive instruments, the magnitude of the vibration is orders of magnitude below the human level of perception and does not pose any risk to human health.

10.3 ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA

10.3.1 Scoping Responses and Consultations

Consultation for this EIA Report topic was undertaken with the organisations shown in Table 10.1.

[12] Renewable UK, 2013: Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effects
[13] Institute of Acoustics, (2016) A Method for Rating Amplitude Modulation in Wind Turbine Noise
[14] BEIS, (2016), Review of the evidence on the response to amplitude modulation from wind turbines.
[15] ETSU (1997), Low Frequency Noise and Vibrations Measurement at a Modern Wind Farm, prepared by D J Snow.
[16] Microseismic and infrasound monitoring of low frequency noise and vibrations from wind farms: recommendations on the siting of wind farms in the vicinity of Eskdalemuir, Scotland". Keele University, 2005

Table 10.1 Consultation Responses

Consultee	**Highland Council, Environmental Health**	
Type and Date	**Scoping Response 23 April 2019**	
Topic	**Comment**	**Response**
Operational Noise	The applicant will be required to submit a noise assessment with regard to the operational phase of the development. The assessment should be carried out in accordance with ETSU-R-97 "The Assessment and Rating of Noise from Wind Farms" and the associated Good Practice Guide published by the Institute of Acoustics.	The stated guidance has been Followed, as discussed in Section 10.2.2.2.
	The target noise levels are either a simplified standard of 35dB LA90 at wind speeds up to 10 m/s or a composite standard of 35dB LA90 (daytime) and 38dB LA90 (night time) or up to 5dB above background noise levels at up to 12m/s. The night time lower limit of 43dB LA90 as suggested in ETSU is not considered acceptable in many areas of the highlands due to very low background levels. These limits would apply to cumulative noise levels from more than one development.	As discussed in Section 10.3.8.2, the assessment has been carried out using the simplified criterion of 35 dB, $LA_{90,10min}$.
Cumulative Noise	The noise assessment must take into account the potential cumulative effect from any other existing or consented or, in some cases, proposed wind turbine developments. Where applications run concurrently, developers and consultants are advised to consider adopting a joint approach with regard to noise assessments. The noise assessment must take into account predicted and consented levels from such developments. The good practice guide offers guidance on how to deal with cumulative issues. Where existing development has consented limits higher than suggested above, the applicant should agree appropriate limits with the Council's Environmental Health Officer.	The methodology used in the assessment of cumulative noise is discussed in Section 10.3.2.4 and follows the approach specified in the comment.
	The assessment should include a map showing all wind farm developments which may have a cumulative impact and all noise sensitive properties including any for which a financial involvement relaxation is being claimed.	See Figure 10.1.
	The assessment should include a table of figures which includes the following: • The predicted levels from this development based at each noise sensitive location (NSL) at wind speeds up to 12m/s • The maximum levels based on consented limits from each existing or consented wind farm development at each NSL. If any reduction is made for a controlling property or another reason, this should be made clear. • The predicted levels from each existing or consented wind farm development at each NSL. • The cumulative levels based on consented and predicted levels at each NSL.	As the simplified criterion has been applied to cumulative noise, there is no requirement for this level of detail.

	In addition to quantifying cumulative noise levels, the assessment must also consider any increase in noise exposure, for example where there is an existing house with a wind farm to the east and a new wind farm is proposed to the west. If the householder is likely to be subjected to wind turbine noise in all wind conditions with little or no respite then the development may be inappropriate even if recommended noise limits are met.	There are no properties where this situation could occur, see Figure 10.1.
Mitigation	The assessment should also include an outline for a mitigation scheme to be implemented should noise levels from the development be subsequently found to exceed consented levels.	See Section 10.6.2
Background Noise	If background noise surveys are required, these should be undertaken in accordance with ETSU-R-97 and the Good Practice Guide. It is recommended that monitoring locations be agreed with the Council's Environmental Health Officer. Where a monitoring location is to be used as a proxy location for another property, particular care must be taken to ensure it is not affected by other noise sources such as boiler flues, wind chimes, etc. which are not present at that other property. Difficulties can arise where a location is already subject to noise from an existing wind turbine development. ETSU states that background noise must not include noise from an existing wind farm. The GPG offers advice on how to approach this problem and in some cases, it may be possible to utilise the results from historical background surveys. It is advised that the developer consults the Council's Environmental Health Officer at an early stage to discuss the proposed methodology.	As the simplified criterion has been met, no background noise survey is required.
Amplitude Modulation	Research has been carried out in recent years on the phenomenon of amplitude modulation arising from some wind turbine developments. However at this time, the Good Practice guide does not provide definitive Planning guidance on this subject. That being the case, any complaints linked to amplitude modulation would be investigated in terms of the Statutory Nuisance provisions of the Environmental Protection Act 1990.	Amplitude Modulation is discussed in Section 10.2.2.5.
Construction Noise	Planning conditions are not used to control the impact of construction noise as similar powers are available to the Local Authority under Section 60 of the Control of Pollution Act 1974. However, where there is potential for disturbance from construction noise the application will need to include a noise assessment. A construction noise assessment will be required in the following circumstances: - • Where it is proposed to undertake work which is audible at the curtilage of any noise sensitive receptor, out with the hours Mon-Fri 8am to 7pm; Sat 8am to 1pm or • Where noise levels during the above periods are likely to exceed 75dB(A) for short term works or	Construction noise is addressed in Section 10.3.2.1.

	55dB(A) for long term works. Both measurements to be taken as a 1hr LAeq at the curtilage of any noise sensitive receptor. (Generally, long term work is taken to be more than 6 months) If an assessment is submitted it should be carried out in accordance with BS 5228-1:2009 "Code of practice for noise and vibration control on construction and open sites – Part 1: Noise". Details of any mitigation measures should be provided including proposed hours of operation. Regardless of whether a construction noise assessment is required, it is expected that the developer/contractor will employ the best practicable means to reduce the impact of noise from construction activities. Attention should be given to construction traffic and the use of tonal reversing alarms	
Consultee	**Highland Council, Environmental Health**	
Type and Date	**Updated Scoping Opinion, December 2019**	
Comments:	As above.	**Response**: As above.
Consultee	**Highland Council, Environmental Health**	
Type and Date	**Additional Consultation Response, November 2019**	
Topics	**Comment**	**Response**
Cumulative Noise, Criteria and Need for background noise survey.	I can confirm that if there are no other cumulative issues to be considered there would be no requirement for a background survey if noise levels from Ackron are going to be below the simplified standard of 35dB LA90 at noise sensitive properties or 45dB LA90 at financially involved properties. It would be for the planning authority to confirm whether the occupant of any neighbouring property would be eligible for a relaxation of noise limits due to an ongoing financial involvement. To be clear, the above is dependent on there being no other development ahead of Ackron in the Planning system. Where developments are running concurrently in the Planning system it may sometimes be beneficial to look at noise from a joint perspective.	Subsequent to this consultation, an application was submitted for a revised Drum Hollistan Wind Farm. This has been taken into account in the cumulative assessment, but has a minimal effect on the receptors relevant to the Development. The cumulative noise effects of the Development and Drum Hollistan 2 are discussed in Section 10.7.

10.3.2 Scope of Assessment

10.3.2.1 Construction Noise and Vibration

The minimum distance between the Development and nearby noise receptors is approximately 0.9 km and 1.7 km from the closest proposed turbine to the nearest involved and non-involved receptor respectively, and 425 m and 490 m from the nearest point on the access track to nearest involved and non-involved receptor respectively. Therefore, it is unlikely that construction noise levels would exceed the levels specified in The Highland Council's (the Council) Environmental Health Officer (EHO) Scoping Opinion (see Table 10.1). Furthermore, construction will not take place outside of those times specified in the Council EHO Scoping Opinion (Table 10.1). Therefore, rather than assessing the effects of construction noise in terms of noise level, the mitigation measures

outlined in Section 10.6.1 are to be adopted, which are considered to be best practice, as advocated in BS 5228.

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

Noise from construction traffic on public roads has been assessed as described at **Error! Reference source not found.**

10.3.2.2 Operational Noise

Typically, the operational noise assessment process comprises of:

i) Identification of potential receptors, i.e. residential properties and other potentially noise-sensitive locations;
ii) Measurement of prevailing, wind speed dependant background noise levels at nearby properties;
iii) Establishment of limits for acceptable levels of wind turbine noise, based on the measured background noise levels and appropriate fixed lower limits;
iv) Prediction of the likely levels of wind turbine noise received at each receptor; and
v) Comparison of the predicted levels with the noise limits.

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

It has been agreed through consultation with the Council's Environmental Health Department that a simplified criterion of 45 dB $L_{A90,10min}$ can also be applied to receptors where the occupier has a financial interest in the Development. This simplified criterion has been applied where applicable.

10.3.2.3 Operational Noise Sources Other than Wind Turbines

Other sources of operational noise are limited to the on-site substation. The substation will be housed within a building, and located toward the centre of the Development, approximately 1.1 km from the nearest non-involved residential dwelling. Given the low level of noise typically generated by such plant, combined with the attenuation afforded by the substation building and the large separation distance to residential dwellings, no significant substation noise effects are anticipated; substation noise has therefore not been considered further.

10.3.2.4 Cumulative Noise Assessment

ETSU-R-97 states that the assessment should take account of the effect of noise from all wind turbines that may affect a particular receptor. A list of cumulative sites is provided in Table 6.2 of **Chapter 6: Landscape and Visual**. A screening exercise was conducted to identify any wind turbines either operational, consented, or proposed (i.e. subject of a current planning application)[17], considered to have the potential to result in cumulative noise impacts when assessed in conjunction with the Development. No such developments were identified; however, Arcus is aware that an application for a re-designed Drum Hollistan 2 Wind Farm was submitted in February 2020 (20/00645/FUL).

The EIA Report for Drum Hollistan 2[18] presents the Enercon E115 with a hub height of 67 m as a candidate turbine. However, there are discrepancies between the data for this turbine model presented in Chapter 8 of the EIA Report and the manufacturer's data

[17] Status of wind farms is as of 15 September 2020.
[18] Drum Hollistan 2 Wind Farm, EIA Report Volume 2: Written Statement, February 2020, Chapter 8: Noise

presented in the EIA Report Appendix 8.5. The worst-case of these, the data from Appendix 8.5, has been applied in this assessment and is detailed in Section 10.3.6.

The GPG states that cumulative assessment is required in areas where the predicted cumulative noise level (including the Development) is greater than 35 dB(A), and the difference in predicted noise levels between the developments and other sites is less than 10 dB. Figure 10.1 shows the areas in which the predicted cumulative noise levels is 35 dB or greater and where noise from the Development is predicted to be within 10 dB of Drum Hollistan. Cumulative assessment is required in the overlap of such areas.

10.3.3 Elements Scoped Out of Assessment

As stated in Section 10.3.2.1, construction noise and vibration has been scoped out of the assessment, other than noise from construction traffic.

As the simplified criterion has been applied, the measurement of background noise levels has been scoped out of the assessment.

10.3.4 Study Area

Construction traffic noise effects have been assessed at the Traffic Count Locations identified in Figure 11.3.

The Study Area for the operational noise assessment is defined in Figure 10.1. This comprises the area where noise levels from the Development are predicted to be within 10 dB of, or 10 dB greater, than those from other relevant wind energy developments and the predicted cumulative wind farm noise level is greater than 35 dB, $L_{A90,10min}$. This is illustrated on Figure 10.1 by the areas shaded orange and green, and bounded by the purple contour line.

10.3.5 Design Parameters

The GPG notes that most sites at planning stage will not have selected a preferred turbine, therefore a candidate turbine representative of a range of turbines should be selected to provide appropriate noise levels. Once noise levels have been predicted at the potentially affected properties, compliance with noise limits can be assessed and design advice provided if compliance with the limits is considered unlikely.

The Vestas V136 4.0 / 4.2 MW turbine with a hub height of 82 m has been selected as the candidate turbine for this assessment. This assessment assumes the turbines are fitted with the Serrated Trailing Edge (STE) blades, and operate at full power (Mode 0) at all times. The manufacturer's data excludes any margin for uncertainty, and as such an additional 2 dB has been included in the sound power levels in this assessment, as detailed in Table 10.2.

Table 10.2: Manufacturer's Noise Emission Data – Vestas V136 4.0 / 4.2 MW, 82 m Hub Height

	Standardised 10 m Wind Speed, ms^{-1}								
	4	5	6	7	8	9	10	11	12
	Sound Power Level, dB(A)								
Sound Power Level, dB LWA, Mode 0	94.6	99.5	103.2	103.9	103.9	103.9	103.9	103.9	103.9
Sound Power Level, dB, LWA, inc. 2 dB allowance for uncertainty	96.6	101.5	105.2	105.9	105.9	105.9	105.9	105.9	105.9

The octave-band frequency spectrum at the wind speed for which the maximum sound power level is achieved (7 ms^{-1} @ 10 m) is detailed in Table 10.3.

Table 10.3: Octave-band Spectra

	Octave-band Centre Frequency, f, Hz							
	63	125	250	500	1000	2000	4000	8000
	Octave-band Sound Power Level, dB, $L_{WA,f}$							
Sound Power Level, dB, LWA	84.3	92.3	97.3	99.2	98.1	93.9	86.9	76.6
Sound Power Level, dB, LWA, Scaled to 105.9 dB(A)	86.3	94.3	99.3	101.2	100.1	95.9	88.9	78.6

10.3.6 Cumulative Developments

Tables 10.4 and 10.5 detail the noise emissions assumed for Drum Hollistan 2 Wind Farm. As the manufacturer's data sheet states an uncertainty of 1 dB, an addition of 1.6 dB has been applied in accordance with the GPG (i.e. 1.645 times the stated uncertainty of 1 dB).

Table 10.4: Manufacturer's Noise Emission Data – Enercon E115 Operating Mode 0s (Drum Hollistan 2)

	Standardised 10 m Wind Speed, ms^{-1}								
	4	5	6	7	8	9	10	11	12
	Sound Power Level, dB(A)								
Sound Power Level, dB LWA, Mode 0	92.8	99.6	101.7	104.4	105.1	105.7	106.0	106.0	106.0
Sound Power Level, dB, LWA, inc. 1.6 dB allowance for uncertainty	94.4	101.2	103.3	106.0	106.7	107.3	107.6	107.6	107.6

The octave-band frequency spectrum at the wind speed for which the maximum sound power level is achieved (10 ms^{-1} @ 10 m) is detailed in Table 10.5.

Table 10.5: Octave-band Spectra (Drum Hollistan 2)

	Octave-band Centre Frequency, f, Hz							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
	Octave-band Sound Power Level, dB, $L_{WA,f}$							
Sound Power Level, dB, LWA	89.2	95.0	98.0	100.3	100.2	98.3	91.7	76.8
Sound Power Level, dB, LWA, Scaled to 107.6 dB(A)	90.8	96.6	99.6	101.9	101.8	99.9	93.3	78.4

10.3.7 Baseline Survey Methodology

10.3.7.1 Receptor Identification

Potential noise-sensitive receptors have been identified using Ordnance Survey MasterMap AddressBase, a database which combines the locations of buildings and other features from large-scale digital mapping with the Royal Mail's address database, along with aerial photography and site visits.

The Applicant, Ackron Wind Farm Ltd., has informed Arcus that the occupiers of Golval and Ackron Farm have a financial interest in the Development.

10.3.7.2 Baseline Noise Survey

As predicted cumulative noise levels from the Development and Drum Hollistan 2 Wind Farm (as shown in Figure 10.1) would not exceed the simplified criteria of 35 dB(A) at non-involved properties and 45 dB(A) at involved properties, no baseline noise measurements are required.

10.3.8 Methodology for the Assessment of Effects

10.3.8.1 Construction Traffic

Noise from construction traffic on public roads has been assessed on the basis of the change in traffic noise levels due to the addition of traffic associated with construction of the Development. This has been carried out for a number of assessment locations, as outlined in **Chapter 11: Access, Transport and Traffic** and shown on Figure 11.3. Baseline traffic flows for each location have also been sourced from **Chapter 11**. The percentage increases in all traffic and for HGVs have then been used together with the number of vehicles, proportion of HGVs and likely speed (based on the type of road) to calculate the likely change in traffic noise level due to construction traffic for the predicted peak month of the construction programme as a worst case, using the method described in Calculation of Road Traffic Noise (CRTN)[19].

Throughout the construction phase of the Development, deliveries of concrete will occur periodically, increasing vehicle flows above that during the peak month when no deliveries take place. As such, assessment of the peak month daily construction traffic including concrete delivery has also been included. As outlined in Section 11.7.1 of **Chapter 11**, deliveries of concrete are anticipated to occur on a maximum of 11 non-consecutive days.

In the event that on-site concrete batching is employed, the increases in traffic assessed for concrete delivery days would not occur.

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

Cumulative construction traffic flows have also been provided in Section 11.9 of **Chapter 11: Access, Transport and Traffic**, taking into account potential baseline and peak month construction traffic for other nearby wind energy developments (as shown in Appendix A11.2), assuming their construction coincides with Ackron Wind Farm. The cumulative peak month flow excludes concrete deliveries as it is assumed that such activities for each development will be timed to ensure they do not coincide.

10.3.8.2 Construction Traffic Noise Significance Criteria

The magnitude of effects, in terms of the predicted change in traffic noise levels on public roads, expressed as $L_{A10,18hour}$ in accordance with CRTN, and based on criteria defined in DMRB[20] are defined as follows:

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

Effects of Moderate or Major magnitude are considered to be significant in terms of the EIA Regulations[21]. Effects of Negligible or Minor magnitude are considered to be not significant in terms of the EIA Regulations.

It should be noted that the approach detailed above is not appropriate for the assessment of noise from traffic on roads with existing low traffic flows (i.e. fewer than 1000 vehicles/day[22]). In this situation, the absolute level of noise provides a better indicator of the potential for disturbance than would the change in traffic noise level. Therefore, in this situation, construction traffic noise levels have been calculated using the BS 5228 methodology at a reference distance of 10 m from the road and assessed using the criteria employed for general construction noise. Using this method, noise levels generated by construction traffic are deemed to be significant if the $L_{Aeq,period}$ level of construction traffic noise exceeds lower threshold values of 65 dB(A) during daytime (includes 0700 to 1300 Saturday)[23], 55 dB(A) during evenings and weekends[24] or 45 dB(A) at night[25].

However, in low background noise environments, it is likely that the pre-existing ambient noise level would be significantly lower than the lower thresholds. It has therefore been assumed that construction traffic noise levels in excess of the lower threshold would also result in total noise levels of more than 5 dB(A) above the pre-existing ambient noise level.

Construction traffic noise levels in excess of the threshold values that would occur for a period of one month or more are regarded as significant in terms of the EIA Regulations.

10.3.8.3 Operational Noise

The acceptable limits for wind turbine operational noise are clearly defined in ETSU-R-97, the methodology for assessment of wind turbine noise recommended by Government guidance. Therefore, this assessment determines whether the calculated immission levels at nearby noise-sensitive receptors lie below the noise limits derived in accordance with ETSU-R-97. Where the noise immission levels at noise-sensitive receptors are shown

[20] Design Manual for Roads and Bridges, Highways Agency / Transport Scotland, Volume II Environmental Assessment, Section 3 Environmental Assessment Techniques, Part 7 HD 213/11, Noise and Vibration – Revision 1, November 2011, Table 3.1 – Classification of Magnitude of Noise Impacts in the Short Term
[21] The Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations, 2011.
[22] CRTN, Para 30.
[23] 0700-1900 weekdays, 0700-1300 Saturdays
[24] 1900-2300 weekdays, 1300-2300 Saturdays and 0700-2300 Sundays
[25] 2300-0700 every day

to be below derived noise limits, the effect is considered to be not significant in terms of the Town and Country Planning (EIA) (Scotland) Regulations 2017[26].

As such, the approach to assessment followed in other technical chapters within this EIA Report is not applicable to the effects of noise, and effects are not considered in terms of their magnitude and the sensitivity of receptors as these factors are implicit in the limits defined by ETSU-R-97.

10.3.8.4 Noise Predictions

Noise predictions have been made using SoundPLAN software (v8.1), which implements the ISO 9613-2[27] methodology and takes account of the specific data and parameters recommended in the GPG, as summarised below:

- The turbine sound power levels should be stated and these should include an appropriate allowance for measurement uncertainty (typically 1.645 times the stated uncertainty). If the data provided contains no allowance for measurement uncertainty, or uncertainties are not stated, an additional 2 dB should be included;
- Atmospheric absorption should be calculated based on conditions of 10°C and 70% relative humidity;
- The ground factor assumed should be G=0.5 (mixed ground) except in urban areas or where noise propagates across large bodies of water, where G=0 (hard ground) should be assumed;
- A receiver height of 4.0 m should be assumed;
- Barrier attenuation should not be included, unless there is no line of sight from the receptor, in which case a 2 dB barrier effect may be included;
- An additional 3 dB should be added to noise immission levels at properties located across a valley or with heavily concave ground between the receptor location and the wind turbine(s)[28]; and
- The predicted noise levels ($L_{Aeq,t}$) should be converted to the required $L_{A90,10min}$ by subtracting 2 dB.

ISO 9613-2 provides a prediction of noise levels likely to occur under worst-case conditions; those favourable to the propagation of sound, i.e. down-wind or under a moderate, ground-based temperature inversion as often occurs at night (often referred to as stable atmospheric conditions). The specific measures recommended in the GPG have been shown to provide good correlation with levels of wind turbine noise measured at operational wind farms[29,30].

10.3.8.5 Assessment Criteria (Noise Limits)

Simplified criteria have been applied to the assessment of operational noise, of:

- 35 dB, $L_{A90,10min}$ at non-involved properties; and
- 45 dB, $L_{A90,10min}$ at involved properties.

10.3.9 Assessment Limitations

No significant assessment limitations have been identified.

[26] Scottish Government (2017) Town and Country Planning (Environmental Impact Assessment) (Scotland) Regulations
2017 [Online] Available at: http://www.legislation.gov.uk/ssi/2017/102/contents/made (Accessed 06/08/2020)
[27] ISO 9613-2:1996 Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation
[28] Equation to determine concave ground as presented in Section 4.3.9 of the GPG.
[29] Bullmore et al. (2009). Wind Farm Noise Predictions and Comparison with Measurements, Third International Meeting on Wind Turbine Noise, Aalborg, Denmark 17 – 19 June 2009.
[30] Cooper & Evans (2013). Effects of different meteorological conditions on wind turbine noise.

10.3.10 Embedded Mitigation

Noise effects were taken into consideration in the design of the Development with the placement of turbines and other sources of operational noise positioned more than 750 m from the two closest properties, Ackron Farm and Golval.

10.4 BASELINE CONDITIONS

Operational noise receptors have been identified as described in Section 10.3.7.1 and are shown in Figure 10.1.

10.5 ASSESSMENT OF POTENTIAL EFFECTS

10.5.1 Cumulative Operational Noise

As can be seen from Figure 10.1, no properties are predicted to experience cumulative operational noise levels in excess of the relevant simplified criteria detailed in Section 10.3.8.2. It can also be seen from Figure 10.1 that receptors to the west of the Development are predominantly affected by the Development and that Drum Hollistan 2 Wind Farm has a minimal effect at these receptors.

10.5.2 Construction Traffic Noise

Tables 10.6 and 10.7 provide the results for the estimated worst-case increase in traffic flows for the peak month at each location and the resulting predicted Magnitude of Effect.

Table 10.6: Predicted Construction Traffic Noise Effects – Non-Concrete Days

Location[31]	Change in Traffic Noise Level, dB	Magnitude of Effect
1 Sordale Point ID: 10800	0.1	Negligible
2 Thurso Bridge Point ID: 40956	0.0	Negligible
3 Pennyland House Point ID: 40800	0.2	Negligible
4 Forss	0.0	Negligible
5 Near Sandside Bay	0.1	Negligible
6 Ackron Farm	Baseline flows <1000, see below	

Table 10.7: Predicted Construction Traffic Noise Effects – Concrete Days

Location[32]	Change in Traffic Noise Level, dB	Magnitude of Effect
1 Sordale Point ID: 10800	0.9	Minor
2 Thurso Bridge Point ID: 40956	0.3	Negligible
3 Pennyland House Point ID: 40800	1.1	Minor
4 Forss	3.5	Moderate
5 Near Sandside Bay	4.6	Moderate

[31] See Figure 11.3 Traffic Count Locations
[32] See Figure 11.3 Traffic Count Locations

Location[32]	Change in Traffic Noise Level, dB	Magnitude of Effect
6 Ackron Farm	Baseline flows <1000, see below	

As detailed in **Chapter 11: Access, Transport and Traffic**, the traffic flow at Location 6 is predicted to be of fewer than 1000 vehicles/day. The CRTN calculation method therefore cannot be used at this location and it is therefore not to appropriate to assess effects in terms of the change in traffic noise level. Noise levels due to traffic at this location has therefore been calculated at 10 m from the road using the BS 5228 methodology and assessed using criteria described in BS 5228.

Table 10.8 details the results of this process for peak month periods with and without concrete deliveries.

Table 10.8: Predicted Construction Traffic Noise Effects – Location 6

Location	Predicted Noise Level, dB, L_{Aeq}
Non-Concrete Days	60
Concrete Days	62

It can be seen from Tables 10.6 to 10.8 that on non-concrete days:

- The predicted change in noise levels at locations 1 to 5 is negligible; and
- The predicted noise level at Location 6 is below 65 dB(A).

On Days where there would be deliveries of concrete:

- The predicted change in noise levels at locations 1 and 3 is minor;
- The change at location 2 is negligible;
- The change at locations 4 and 5 is moderate; and
- The predicted noise level at Location 6 is below 65 dB(A).

Effects on days without concrete deliveries would therefore be **not significant** in terms of the EIA Regulations**.**

However, on days with concrete deliveries, effects would be **significant** at locations 4 and 5. Mitigation for this effect is discussed at 10.6.1.

As discussed in Section 10.3.8.1, assessment of cumulative construction traffic noise has also been carried out and is shown in Table 10.9.

Table 10.9: Predicted Cumulative Construction Traffic Noise Effects

Location[33]	Change in Traffic Noise Level, dB	Magnitude of Effect
1 Sordale Point ID: 10800	1.6	Minor
2 Thurso Bridge Point ID: 40956	0.7	Negligible
3 Pennyland House Point ID: 40800	1.7	Minor
4 Forss	0.5	Negligible
5 Near Sandside Bay	1.0	Minor
6 Ackron Farm	Baseline flows <1000, see below	

[33] See Figure 11.3 Traffic Count Locations

In the case of Location 6, the predicted cumulative construction traffic noise level at 10 m from the roadside is 68 dB(A). However, as stated in Section 11.9 of **Chapter 11**, it is unlikely that all traffic from all cumulative developments would pass this location and therefore the predicted increase in traffic numbers would not occur. Cumulative construction traffic noise is therefore considered to be **not significant** in terms of the EIA Regulations.

10.6 MITIGATION AND RESIDUAL EFFECTS

10.6.1 Construction Noise

Where practicable, the use of on-site concrete batching should be considered in order to reduce traffic numbers and therefore noise. Where this is not practicable, information should be provided to residents and communities located along the A 836 between Thurso and Melvich regarding the dates and times of concrete deliveries. Information may be provided in a variety of means such as: the Development website, local newspapers, posters, signage and direct mailing.

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

- Operations shall be limited to times agreed with the Council;
- Deliveries of turbine components, plant and materials by HGV to site shall only take place by designated routes and within times agreed with the Council;
- The site contractors shall be required to employ the best practicable means of reducing noise emissions from plant, machinery and construction activities, as advocated in BS 5228;
- Where practicable, non-tonal and / or directional reversing alarms should be used;
- Where practicable, the work programme will be phased, which would help to reduce the combined effects arising from several noisy operations;
- Where necessary and practicable, noise from fixed plant and equipment will be contained within suitable acoustic enclosures or behind acoustic screens;
- All sub-contractors appointed by the main contractor will be formally and legally obliged, and required through contract, to comply with all environmental noise conditions;
- Where practicable, night-time working will not be carried out. Local residents shall be notified in advance of any night-time construction activities likely to generate significant noise levels, e.g. turbine erection; and
- Any plant and equipment normally required for operation at night (23:00 - 07:00), e.g. generators or dewatering pumps, shall be silenced or suitably shielded to ensure that the night-time lower threshold of 45 dB, $L_{Aeq,night}$ shall not be exceeded at the nearest noise-sensitive receptors.

In the event that stone is required to be extracted from borrow pits by blasting, the following process would be employed to ensure that the effects of blasting noise and vibration on nearby properties are adequately controlled:

- Compliance with planning conditions specifying limits to vibration resulting from blasting, restrictions on times of blasting, and a requirement for vibration monitoring;
- Trial blasting, using progressively larger charge loads, to establish maximum acceptable charge; and
- Provision of information on blasting to neighbouring residents.

Noise produced during decommissioning of the Development is likely to be of a similar nature to that during construction, although the duration of decommissioning will be shorter than that of construction. Any legislation, guidance or best practice relevant at the time of decommissioning would be complied with.

Residual construction noise effects will therefore be **not significant** in terms of the EIA Regulations.

10.6.2 Operational Noise

No specific mitigation is required for operational noise effects. However, it is recommended that a planning condition is applied limiting noise at the nearest receptors to the following noise levels at wind speeds at 10 m AGL of up to 10 ms^{-1} to:

- 45 dB, $L_{A90,10min}$ at properties where the occupier has a financial interest in the Development; and
- 35 dB, $L_{A90,10min}$ at all other dwellings.

Residual operational noise effects will be **not significant** in terms of the EIA Regulations.

10.7 CUMULATIVE EFFECT ASSESSMENT

Table 6.2 in **Chapter 6: Landscape and Visual** contains details of other wind energy developments within a distance of 25 km from the Development. These are shown on Figure 6.8. The closest operational, consented, or proposed[34] development is Drum Hollistan 2 at a distance of 0.7 km east of the Development.

Cumulative operational noise effects are included in the assessment of operational noise presented above. Due to separation distances, cumulative construction noise effects are **not significant**. Cumulative construction traffic noise effects will be **not significant**.

10.8 SUMMARY OF EFFECTS

An assessment of potential noise effects associated with the Development has been carried out.

Construction noise will be limited in duration and confined to working hours as specified by the Council and therefore can be adequately controlled through the application of good practice measures and secured by planning condition. This will ensure that any noise from the Development site during construction will be adequately controlled.

Construction traffic noise is predicted to be significant on days when concrete deliveries occur. Mitigation is recommended in the form of on-site batching and / or provision of information to residents and communities along the A 836 between Thurso and Melvich.

Operational noise has been assessed in accordance with ETSU-R-97 and in line with current best practice. It has been shown that the Development would comply with the requirements of ETSU-R-97 at all receptor locations.

The cumulative effects of the Development in conjunction with nearby wind energy developments either operational, consented or the subject of a current planning application were taken into consideration in the above assessment, in accordance with ETSU-R-97 and the GPG.

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

[34] i.e., subject of a current valid planning application or appeal with status of wind farms as of 15 September 2020.

10.9 STATEMENT OF SIGNIFICANCE

Construction noise effects have been found to be not significant in terms of the EIA Regulations.

Construction traffic noise effects have been found to be not significant in terms of the EIA Regulations with exception of effects on concrete delivery days which have been found to be significant. Mitigation is recommended in the form of on-site batching and / or provision of information to residents and communities along the A 836 between Thurso and Melvich.

Operational noise effects have been found to be not significant in terms of the EIA Regulations.

Noise during decommissioning will be managed to ensure compliance with best practice, legislation and guidelines current at the time in order to ensure that effects are not significant.

10.10 GLOSSARY

AGL: Above Ground Level

Background Noise: The background noise level is the underlying level of noise present at a particular location for the majority (usually 90%) of a period of time. As such it excludes any short-duration noises, such as individual passing cars (but not continuous traffic), dogs barking or passers-by. Sources of background noise typically include such things as wind noise, traffic and continuously operating machinery (e.g. air conditioning or generators).

Decibel (dB): The decibel is the basic unit of noise measurement. It relates to the cyclical changes in air pressure created by the sound (Sound Pressure Level) and operates on a logarithmic scale, ranging upwards from 0 dB. 0 dB is equivalent to the normal threshold of human hearing at a frequency of 1000 Hz. Each increase of 3 dB on the scale represents a doubling in the Sound Pressure Level, and is typically the minimum noticeable change in sound level under normal listening conditions. For example, while an increase in noise level from 32 dB to 35 dB represents a doubling in sound pressure level, this change would only just be noticeable to the majority of listeners.

dB(A): Environmental noise levels are usually discussed in terms of dB(A). This is known as the A-weighted sound pressure level, and indicates that a correction factor has been applied, which corresponds to the human ear's response to sound across the range of audible frequencies. The ear is most sensitive in the middle range of frequencies (around 1000-3000 Hertz (Hz)), and less sensitive at lower and higher frequencies. The A-weighted noise level is derived by analysing the level of a sound at a range of frequencies and applying a specific correction factor for each frequency before calculating the overall level. In practice this is carried out automatically within noise measuring equipment by the use of electronic filters, which adjust the frequency response of the instrument to mimic that of the ear.

Frequency: The frequency of a sound is equivalent to its pitch in musical terms. The units of frequency are Hertz (Hz), which represents the number of cycles (vibrations) per second.

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

Noise Immission: The sound pressure level detected at a given location (e.g. nearest dwelling).

$L_{A90,t}$: This term is used to represent the A-weighted sound pressure level that is exceeded for 90% of a period of time, t. This is used as a measure of the background noise level.

$L_{Aeq,t}$: This term is known as the A-weighted equivalent continuous sound pressure level for a period of time, t. It is similar to an average, and represents the sound pressure level of a steady, continuous noise which has the same energy as the actual measured noise.

Low-frequency noise: Noise at the lower end of the range of audible frequencies (20 Hz – 20 kHz). Usually refers to noise below 250 Hz. Should not be confused with infrasound, which is sound below the lowest normally audible frequency, 20 Hz.

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

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

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

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

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

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

Tonal element: A characteristic of a sound where the sound pressure level in a particular frequency range is greater than in those frequency ranges immediately above higher or lower. This would be perceived as a humming or whining sound.

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