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30 YEARS

CONSULTANTS IN ENGINEERING, ENVIRONMENTAL SCIENCE & PLANNING

ENVIRONMENTAL IMPACT ASSESSMENT REPORT (EIAR) FOR THE PROPOSED CROAGHAUN WIND FARM, CO. CARLOW

VOLUME 2 – MAIN EIAR

CHAPTER 7 – NOISE AND VIBRATION

Prepared for: Coillte

COILLTE
GROW · TRANSFORM · SUSTAIN

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Core House, Pouladuff Road, Cork
T12 D773, Ireland

T: +353 21 496 4133 E: info@ftco.ie

CORK | DUBLIN | CARLOW

www.fehilytimoney.ie

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7. NOISE AND VIBRATION

7.1 Introduction

This chapter contains an assessment of the potential noise and vibration impacts associated with the proposed Croaghaun Wind Farm project excluding the replanting lands that are assessed in Appendix 3.3 and 3.4. The assessment including undertaking of background noise surveys has been carried out by Fehily Timoney and Company in accordance with current guidance and best practice. A detailed description of the project assessed in this EIAR is provided in Chapter 3 and is comprised of three main elements:

- The wind farm (hereinafter referred to as the **'main wind farm site'**);
- Turbine delivery route (hereinafter referred to as the **'turbine delivery route'** or **'TDR'**);
- Grid connection (hereinafter referred to as the **'grid connection'**.

The main wind farm site includes the wind turbines, internal access tracks, hard standings, the permanent meteorological mast, recreational amenity trail and associated signage, onsite substation, internal electrical and communications cabling, temporary construction compound, drainage infrastructure and all associated works related to the construction of the wind farm. The grid connection includes the buried grid connection cable route from the on-site substation to the existing grid substation at Kellistown, Co. Carlow and the proposed off-site substation, also at Kellistown. The turbine delivery route includes all aspects of the route from the M11/N30 junction to the site entrance including proposed temporary accommodation works to facilitate the delivery of wind turbine components. Replanting lands at Sroove Co. Sligo and Crag Co. Limerick have also been assessed for cumulative impacts. Reports detailing environmental assessments carried out on these sites are contained in Appendix 3.3 and 4.4 of this EIAR.

Potential construction noise and vibration impacts have been determined with reference to British Standard 5228:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites Part 1 Noise.

Potential operational noise impacts associated with the proposed project have been determined with reference to the UK Institute of Acoustics', A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (2013). Operational noise associated with the proposed project includes noise from the proposed wind turbines and on-site substation. The operational noise is compared with noise limits derived in accordance with the Wind Energy Development Guidelines 2006.

The noise limits provided in the Wind Energy Development Guidelines 2006 are being revised. The Draft Revised Wind Energy Development Guidelines were published on the 19th December 2019. The 2019 draft guidelines were out to public consultation until the 19th February 2020 and may be subject to further revision. The final version of 2019 draft guidelines have not yet been issued. As such, the noise limits from the 2006 guidelines are used in this assessment as they are the current ones the board must have regard to and they are still accepted as appropriate within the expert community. Furthermore, the 2019 draft guidelines have a number of technical errors, ambiguities and inconsistencies and requires further detailed review and amendment. If new Guidelines are adopted prior to a decision on this application, Coillte are happy to demonstrate compliance with same as appropriate.

Operational noise associated with the proposed substation at Kellistown has been assessed with reference to BS 4142:2014+A1:2019 *Methods for Rating and Assessing Industrial and Commercial Sound*.

Decommissioning noise and vibration impacts have been assessed with the same standards used to determine construction noise and vibration impacts.

7.2 Description of Noise and Vibration Impacts

7.2.1 Construction Noise & Vibration

Noise is generated from the construction of the turbine foundations, the erection of the turbines, the excavation of trenches for cables, extraction of material from borrow pits, horizontal directional drilling, temporary bridge works, felling, the construction of associated hardstandings and access tracks, and construction of the substations.

Noise from vehicles on local roads and access tracks is also generated from the delivery of the turbine components and construction materials, notably aggregates, concrete and steel reinforcement.

Vibration is generated by construction activities such as rock breaking and passing heavy goods vehicles. The threshold of human perception of vibration is in the range of 0.14mm/s to 0.3mm/s , described as “might just be perceptible”. The guideline values for damage to buildings from vibration are 15mm/s at 4Hz increasing to 20mm/s at 15Hz and 50mm/s at 40Hz and above.

Typical vibration generated from construction activities for the proposed Croaghaun Wind Farm are:

- Tracked excavators and disc cutters from cable trenching (0.8 mm/s at 4m)
- Pneumatic breakers for cable trenching (0.7 mm/s at 10 m)
- Rock breaking at borrow pits (0.03 mm/s at 100 m)
- Excavation of turbine foundations (0.06 mm/s at 100 m)
- HGV traffic on normal road surfaces (0.01 to 0.5 mm/s) at footings of buildings located 20 m from roadway.

The nearest noise sensitive locations are sufficiently distant that vibration will not be perceivable by residents at their dwellings and building damage will not occur from construction incurred vibration. As such, construction vibration will not be considered further in this chapter.

7.2.2 Operational Noise & Vibration

Noise is generated by wind turbines as they rotate to generate power. This only occurs above the ‘cut-in’ wind speed and below the ‘cut-out’ wind speed. Below the cut-in wind speed there is insufficient strength in the wind to generate efficiently and above the cut-out wind speed the turbine is automatically shut down to prevent any malfunctions from occurring. The cut-in speed at the turbine hub-height is approximately 3 m/s and the cut-out wind speed is approximately 25 m/s.

The principal sources of noise are from the blades rotating in the air (aerodynamic noise) and from internal machinery, normally the gearbox and, to a lesser extent, the generator (mechanical noise).

The blades are carefully designed to minimize noise whilst optimising power transfer from the wind. See Oerlemans et al. (2008) 'Location and quantification of noise sources on a wind turbine' for further details on the principal sources of noise from a wind turbine.

Noise may also be generated from ancillary equipment such as transformers at on-site substations. However, these generally have low source noise levels compared to wind turbines themselves and, provided they are not located within the immediate vicinity of a residential dwelling, are unlikely to cause disturbance in the context of the other noise sources.

7.2.3 Wind Turbine Noise Characteristics

7.2.3.1 Blade Swish (Amplitude Modulation of Aerodynamic Noise)

This is the periodic variation in noise level associated with turbine operation, at the rate of the blade passing frequency (rotational speed multiplied by number of blades). It is often referred to as blade swish or amplitude / aerodynamic modulation (AM). This effect is discussed in ETSU-R-97, 'The Assessment and Rating of Noise from Wind Farms' (1996), which states that '… modulation of blade noise may result in variation of the overall A-Weighted noise level by as much as 3 dB(A) (peak to trough) when measured close to a wind turbine... ' and that at distances further from the turbine where there are'… more than two hard, reflective surfaces, then the increase in modulation depth may be as much as 6 dB(A) (peak to trough)'. It concludes that 'the noise levels (i.e. limits) recommended in this report take into account the character of noise described ... as blade swish'.

An observer close to a wind turbine will experience 'blade swish' because of the directional characteristics of the noise radiated from the trailing edge of the blades as it rotates towards and then away from them.

This effect is reduced for an observer on or close to the (horizontal) turbine axis, and therefore would not generally be expected to be significant at typical separation distances, at least on relatively level sites.

In some cases amplitude modulation is observed at large distances from a wind turbine (or turbines). The sound is generally heard as a periodic 'thumping' or 'whoomphing' at relatively low frequencies. This is known as 'Other AM or OAM'. It was proposed in the RenewableUK 2013 study that the fundamental cause of OAM is transient stall conditions occurring as the blades rotate, giving rise to the periodic thumping at the blade passing frequency. Transient stall represents a fundamentally different mechanism from blade swish and can be heard at relatively large distances, primarily downwind[1] of the rotor blade.

The University of Salford carried out a study on behalf the Department for Business, Enterprise and Regulatory Reform (BERR) to investigate the prevalence of amplitude modulation of aerodynamic noise on UK wind farm sites. The study concluded that AM has occurred at 4 out of 133 wind farms in the UK. A further investigation of the four sites by the Local Authority showed that the conditions associated with AM might occur between 7% and 15% of the time.

The most recent research into AM was conducted by RenewableUK, 'Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect' (December 2013).

This research focused on the less understood 'Other AM or OAM' where reported incidents are relatively limited and infrequent but is a recognised phenomenon. However, the occurrence and intensity of Other AM is specific to a location and its likelihood of occurrence cannot be reliably predicted.

[1] The stall source mechanism radiates equally upwind and downwind, but propagation effects reduce noise levels upwind.

Section 6 of the 'Summary of Research into Amplitude Modulation of Aerodynamic Noise from Wind Turbines - Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect' states that 'At present there is no way of predicting OAM at any particular location before turbines begin operation due to the general features of a site or the known attributes of a particular turbine.'

However, the Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3) states….

'features which are thought to enhance this effect are:

- *close spacing of turbines in linear rows*
- *tower height to rotor diameter ratio less than approximately 0.75*
- *stable atmospheric conditions*
- *topography leading to different wind directions being seen by the blades at different points in their rotation'*

The RenewableUK study 'has found that by minimising the onset of blade stall, the occurrence of OAM is also likely to be minimised.' It goes on to discuss 'the future involvement of turbine manufacturers in developing methods of avoiding or minimising the partial stall mechanism identified as a primary cause of OAM; and suggests that in future changes to blade design and the way in which the blade pitch (the angle of attack of the blade to the incoming air flow) is controlled are likely to have a role to play in achieving better management of the phenomenon.' Ultimately, further work is required to identify the exact on-blade conditions required for OAM to occur. The further work will aid in the development of a measure to fully mitigate the OAM. If OAM occurs from the proposed project, the wind turbine(s) will be operated in a manner to address this.

In 2016, the IoA published 'A Method for Rating Amplitude Modulation in Wind Turbine Noise'. It sets out a procedure for obtaining input noise data. The procedure proposed in the IoA guidance document is recommended by the Department of Business, Energy & Industrial Strategy (BEIS) who have published a study on amplitude modulation.

At present there is no method for predicting OAM at any particular location before turbines begin operation based on? the general features of a site or the known attributes of a particular turbine. In the unlikely event of OAM being present and following establishment of the likely cause, this can be addressed by turbine manufacturers and/or operator as and when it occurs.

7.2.3.2 Infrasound & Low Frequency Noise

The definition of low frequency noise can vary, but it is generally accepted that low frequency noise is noise that occurs within the frequency range of 10 Hz to 160 Hz.

Infrasound is noise occurring at frequencies below that at which sound is normally audible, that is, less than about 20 Hz, due to the significantly reduced sensitivity of the ear at such frequencies. In this frequency range, for sound to be perceptible, it must be at very high amplitude, and it is generally considered that when such sounds are perceptible then they can cause considerable annoyance. However, wind turbines do not produce infrasound at amplitudes capable of causing annoyance as outlined in the following paragraphs.

The UK Department of Trade and Industry study, 'The Measurement of Low Frequency Noise at Three UK Windfarms', concluded that:

> *infrasound noise emissions from wind turbines are significantly below the recognised threshold of perception for acoustic energy within this frequency range. Even assuming that the most sensitive members of the population have a hearing threshold which is 12 dB lower than the median hearing threshold, measured infrasound levels are well below this criterion.*

It goes on to state that, based on information from the World Health Organisation, 'there is no reliable evidence that infrasound below the hearing threshold produce physiological or psychological effects' and that 'it may therefore be concluded that infrasound associated with modern wind turbines is not a source which may be injurious to the health of a wind farm neighbour'.

The study reports that low frequency noise is measurable but below the DEFRA[2] low frequency noise criterion. The study also assessed low frequency measurements against the Danish criterion of LpA,LF = 20 dB. It was found that internal levels do not exceed 20dB when measurements are undertaken within rooms with the windows closed. However, the study acknowledges that wind turbine noise (low frequency) may result in an internal noise level that is just above the threshold of audibility as defined in ISO 226. The study goes on to say… 'However, at all the measurement sites, low frequency noise associated with traffic movement along local roads has been found to be greater than that from the neighbouring wind farm.'

Bowdler et al. (2009) 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'.

In January 2013, the Environmental Protection Authority of South Australia published the results of a study into infrasound levels near wind farms. Measurements were undertaken at seven locations in urban areas and four locations in rural areas including two residences approximately 1.5 km from the wind turbines. The study concluded 'that the level of infrasound at houses near the wind turbines… is no greater than that experienced in other urban and rural environments and is also significantly below the human perception threshold.'

In 2016, the State Office for the Environment, Measurement and Nature Conservation of the Federal State of Baden-Württemberg in Germany published a report entitled 'Low-frequency noise incl. infrasound from wind turbines and other sources.' It assessed infrasound and low frequency sound from wind turbines and other sources. It found that for 'the measurements carried out even at close range, the infrasound levels in the vicinity of wind turbines – at distances between 150 and 300 m – were well below the threshold of what humans can perceive in accordance with DIN 45680 (2013).'

We conclude that infrasound noise emissions from wind turbines are significantly below the recognised threshold of perception for acoustic energy within this frequency range. Infrasound is not a source which may be injurious to the health of a wind farm neighbour.

Wind turbines may produce low frequency noise at levels above the threshold of audibility. However, there is no evidence of health effects arising from low frequency noise generated by wind turbines. Given the evidence described above, an assessment of infrasound and low frequency noise from the wind farm has been scoped out.

[2] Department of Environment, Food & Rural Affairs, UK

7.2.3.3 Tonal Noise

ETSU-R-97 describes tonal noise as "noise containing a discrete frequency component most often of mechanical origin". Wind turbine sound can be tonal in some cases, for example if there is a defect in a turbine blade or a fault in the mechanical equipment such as the gearbox. Tonality from wind turbines is generally caused by structural resonances in the mechanical parts of the turbine and thus is highly specific not only to the turbine model but the specific components used, including tower height. However, a correctly operating wind turbine is not considered to have tonal sound emissions. In the event of tonal noise being present and following establishment of the likely cause, this can be addressed by turbine manufacturers and/or operator as and when it occurs.

7.2.4 Vibration

Vibration from operational wind turbines is low and will not result in perceptible levels at nearby sensitive receptors nor will the levels of vibration result in any structural damage. Research undertaken by Snow 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. Hence, the level of vibration produced by wind turbines at this distance is low and does not pose a risk to human health.

More recently, the Low Frequency Noise Report published by the Federal State of Baden-Württemberg simultaneously measured vibration at several locations, ranging from directly at the wind turbine tower to up to 285m distance from an operational Nordex N117 – 2.4 MW wind turbine with a hub height of 140.6m. The report concluded that at less than 300m from the turbine, the vibration levels had reduced such that they could no longer be differentiated from the background vibration levels.

Considering that the nearest sensitive receptor is over 950m from the nearest turbine, the level of vibration is significantly below any thresholds of perceptibility. Vibration from the turbines is too low to be perceived at neighbouring residential dwellings.

Vibration levels will also be significantly below levels that would result in damage to the nearest buildings (including farm buildings). Therefore, operational vibration has been scoped out.

7.2.5 Decommissioning Noise & Vibration

The impacts associated with decommissioning of the project are comparable to those described for the construction phase but to a lesser extent.

7.3 Methodology

The methodology adopted for this noise and vibration assessment is as follows:

- Review of appropriate guidance and specification of suitable construction and operational noise / vibration criteria;
- Characterisation of the receiving noise environment;

- Prediction of the noise impact associated with the proposed project;
- Evaluation of noise impacts,
- Propose mitigation, and
- Assess residual impacts.

7.3.1 Relevant Guidance

A list of relevant guidance documents is provided below. These have been referred to where referenced or applied in the sections hereafter.

EIA Guidance:

- Guidelines on the information to be contained in Environmental Impact Assessment Reports, Environmental Protection Agency (Draft), 2017
- Advice Notes on Current Practice, Environmental Protection Agency, Draft 2015
- Environmental Impact Assessment of Projects - Guidance on the preparation of the Environmental Impact Assessment Report (Directive 2011/92/EU as amended by 2014/52/EU).

Noise Modelling Standards and Technical Advice:

- International Standard *ISO 9613-2: 1996 Attenuation of sound during propagation outdoors, Part 2: General method of calculation*
- UK Institute of Acoustics', *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment at Rating of Wind Turbine Noise* (2013) and supplementary notes
- British Standard *BS 5228 Part 1:2009+A1:2014 Code of practice for noise and vibration control on construction and open sites Part 1: Noise*
- Irish Wind Energy Association, *Best Practice Guidelines for the Irish Wind Energy Industry* (2012)
- UK Department of Trade and Industry (DTI), ETSU-R-97, *The Assessment and Rating of Noise from Wind Farms* (1996)
- British Standard BS 4142:2014+A1:2019, *Methods for Rating and Assessing Industrial and Commercial Sound*

Guideline Noise Levels:

- Wind Energy Development Guidelines, Department of the Environment, Heritage and Local Government (2006)
- Carlow County Development Plan 2015 - 2021
- Carlow County Council's Wind Strategy

7.3.2 Study Area

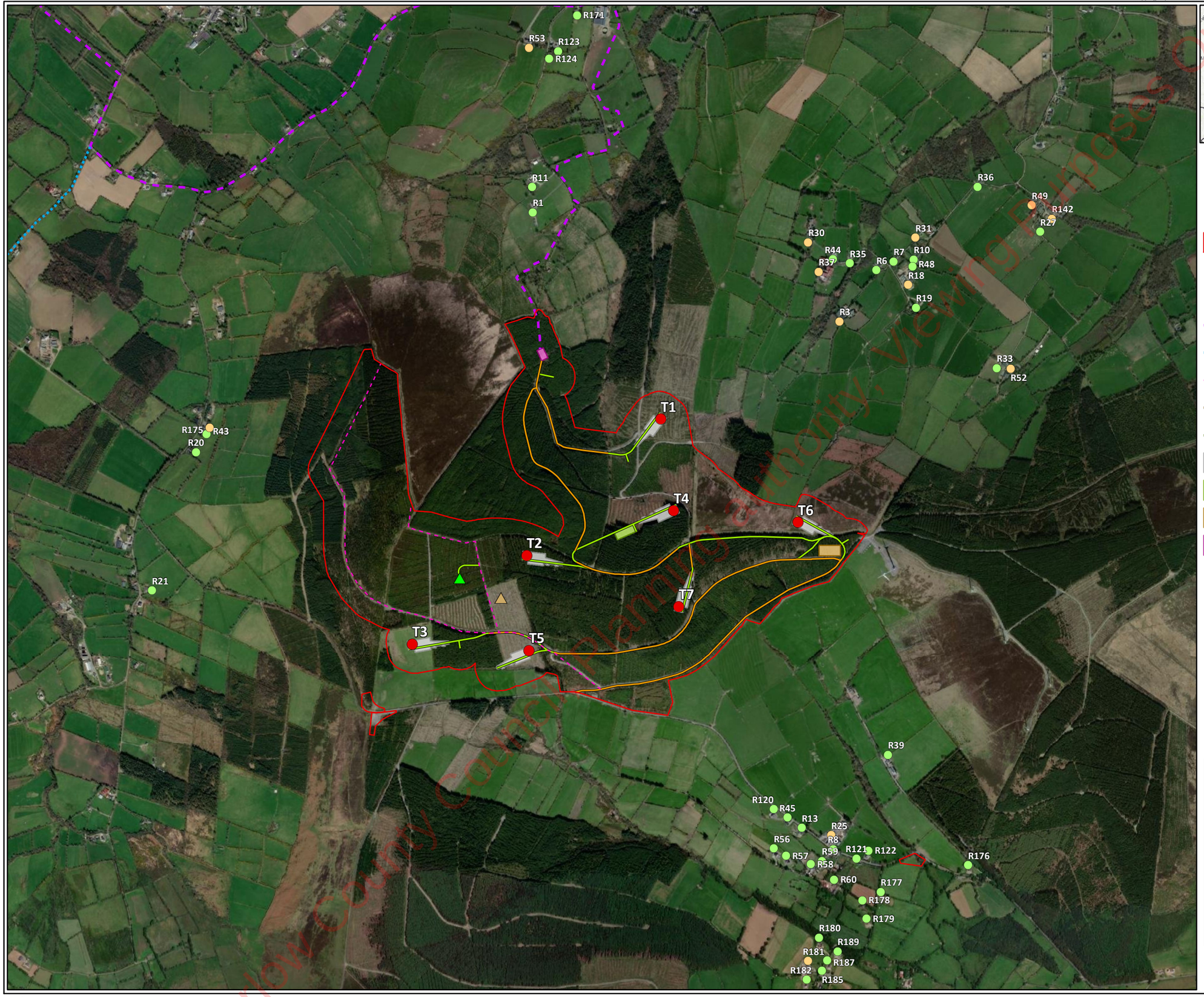
Construction and decommissioning noise have been assessed by comparing predicted construction activity activities against best practice construction noise criteria at the nearest residential dwellings to the construction activities. As such, if the construction noise meets the relevant noise limits at the nearest locations, it will also be below the relevant noise limits at more distant residential locations.

The operational noise study area includes all residential dwellings with a predicted noise level greater than 35 dB L_{A90} (which is the lowest limit prescribed in the 2006 Department of the Environment, Heritage, and Local Government, *Wind Energy Development Guidelines*). The study area is also in accordance with the UK Institute of Acoustics' *A Good Practice Guide to the Application of ETUS-R-97 for the Assessment at Rating of Wind Turbine Noise* (2013) whereby the guidance document defines the study area as "*the area within which noise levels from the proposed, consented and existing wind turbine(s) may exceed 35dB L_{A90} at up to 10 m/s wind speed*."

The IOA guidance documents also states… *"During scoping of a new wind farm development consideration should be given to cumulative noise impacts from any other wind farms in the locality. 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."* Greenoge Wind Farm consists of 5 turbines and it has been considered in the cumulative assessment and the operational study area of 35 dB L_{A90} includes the noise emissions from Greenoge Wind Farm. The operational study area is presented in Figure 7.1. It includes 51 noise sensitive locations.

Since construction and operational vibration have been scoped out, there is no requirement to set study areas for each.

Path: R:\Map Production\2019\P1913\Workspace\EIAR\P1913_GIS_Fig7-1_NoiseSensitiveLocations_A3.mxd



- Residential
- Residential/Commercial
- Proposed Turbine Layout
- Proposed Development Boundary
- Existing 80m Met Mast
- Proposed Permanent 100m Met Mast
- Proposed Grid Connection Route
- Grid Connection Route Variant 1
- Proposed Croaghaun Loop
- Proposed Existing Road Upgrade
- Proposed New Road
- Proposed Turbine Hardstanding
- Proposed Borrow Pit
- Proposed Temporary Compound
- Proposed Substation Compound

N W E S

0 0.25 0.5 1 Kilometers

TITLE:	Noise Sensitive Locations		
PROJECT:	Croaghaun Wind Farm		
FIGURE NO:	7.1		
CLIENT:	Coillte		
SCALE:	1:17500	**REVISION:**	0
DATE:	21/10/2020	**PAGE SIZE:**	A3

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7.3.3 Evaluation Criteria

7.3.3.1 Construction Noise Criteria

There is no statutory Irish guidance relating to the maximum permissible noise level that may be generated during the construction phase of a project. In the absence of specific noise limits, appropriate emission criteria relating to permissible construction noise levels for a project of this scale may be found in the British Standard *BS 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites – Noise.* For information it is noted that the proposed approach is in keeping with the *Draft Revised Wind Energy Development Guidelines* (December 2019) published by the Department of Housing, Planning and Local Government which provide details on construction and decommissioning noise criteria. The guidelines state… '*Control of noise during the construction and decommissioning of wind energy developments will be carried out using the ABC method detailed in Annex E.3.2 of BS 5228 [BS 5228-1:2009+A1:2014 Code of Practice for Noise and Vibration Control on Construction and Open Sites – Part 1 Noise]'*.

BS 5228-1:2009+A1:2014 contains several methods for the assessment of the potential significance of noise effects. The ABC Method was used to derive appropriate noise limits for the proposed project. The threshold limit to be applied (as defined in Table 7.1) is dependent on the existing ambient noise levels (rounded to the nearest 5dB).

Table 7.1: Threshold of Potential Significant Effect during Construction and Decommissioning

Threshold value period (L_{Aeq})	Threshold Value, in decibels (dB)		
	Category A	Category B	Category C
Night-time (23:00 - 07:00hrs)	45	50	55
Evenings (19:00 – 23:00 hrs) and weekends (13:00 – 22:00 Saturdays) and (07:00 – 19:00 hrs Sundays)	55	60	65
Daytime (07:00 – 19:00) and Saturdays (08:00 – 16:30)	65	70	75
Note Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values. Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values. Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.			

The approach adopted here calls for the designation of a noise sensitive location into a specific category (A, B or C) based on existing ambient noise levels in the absence of construction noise. For the appropriate period (e.g. daytime), the ambient noise level is determined and rounded to the nearest 5dB.

The baseline noise survey ambient (free-field) noise levels were analysed. A correction of +3dB was added to the noise levels to convert free-field noise levels to façade noise levels. The ambient façade noise level when rounded to the nearest 5dB varies, but for the most part it is less than 60 dB L_{Aeq}. Therefore, the nearest residential dwellings to the proposed project are afforded Category A designation (65 dB $L_{Aeq,1hr}$ during daytime periods).

Section 7.5.2 provides the detailed assessment of construction activity in relation to this site. If the modelled construction noise level exceeds the appropriate category value (e.g. 65 dB $L_{Aeq,1hr}$ during daytime periods) then a potential significant effect is predicted. The assessor then needs to consider other project-specific factors, such as the number of receptors affected and the duration and character of the impact, to determine if there is a significant effect. If a significant effect is determined, mitigation measures are required to reduce the noise levels below the noise limit.

7.3.3.2 Wind Farm Operational Noise Criteria

The operational noise assessment summarised in the following sections has been based on guidance in relation to acceptable levels of noise from wind farms as contained in the document *Wind Energy Development Guidelines* published by the Department of the Environment, Heritage and Local Government (2006).

ETSU-R-97, The Assessment and Rating of Noise from Wind Farms (1996) published by the Department of Trade & Industry (UK) Energy Technology Support Unit (ETSU) and Institute of Acoustics' A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, (May 2013) has been used to supplement the guidance contained within the '*Wind Energy Development Guidelines*' publication where necessary.

In preparing this assessment due consideration has also been given to the Carlow County Development Plan 2015 - 2021. Section 11.18.2 'Wind Development' states… 'All planning applications for wind energy turbines or windfarms shall be assessed against the DoEHLG's publication Wind Energy Development Guidelines, 2006 (and any subsequent guidelines) and Carlow County Council's Wind Strategy (see Appendix 5) and the following' which includes 'Noise Impact'.

The DoEHLG guidelines (2006) contain recommended noise limits to control operational noise from wind farms and state...

> *In general, a lower fixed limit of 45 dB(A) or a maximum increase of 5dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours. However, in very quiet areas, the use of a margin of 5dB(A) above background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments which should be recognised as having wider national and global benefits. Instead, in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of the LA90,10min of the wind energy development noise be limited to an absolute level within the range of 35-40 dB(A).*
>
> *Separate noise limits should apply for day-time and for night-time. During the night, the protection of external amenity becomes less important and the emphasis should be on preventing sleep disturbance. A fixed limit of 43dB(A) will protect sleep inside properties during the night.*

Section 1.6.4 'Noise Issues' of Carlow County Council's Wind Strategy (June 2008) states… '*Noise levels from wind farm developments when measured to the nearest inhabited house should not exceed 40dB (A) (15 minute leq.) at a wind speed of 5m/s and 45dB (A) (15 minute leq.) at wind speeds in excess of 10m/s*'.

The noise limits in the 2006 guidelines are different to those in the Carlow County Council's Wind Strategy. It is recommended that 2006 guidelines are used in line with the broader national requirements.

The limits are summarised below and are stated to be dB $L_{A90,10\ min}$ values:

- 35-40 dB(A) for quiet daytime environments of less than 30 dB(A)
- For daytime environments with background noise levels greater than 30 dB(A), 45 dB(A) or 5 dB(A) above background levels whichever is greater applies
- It is stated that '*A fixed limit of 43 dB(A) will protect sleep inside properties during the night*'

In the absence of detailed guidance from the Wind Energy Development Guidelines 2006, best practice has typically been to consider the guidance contained in ETSU-R-97 and more recently the detailed guidance contained in the Institute of Acoustics 'A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise' (May 2013) and its six supplementary guidance notes, and reference has also been made to planning permission for the adjacent wind farm development.

Where background noise is less than 30 dB(A), an absolute level within the range of 35-40 dB(A) is applicable. However, there is no appropriate approach in relation to the identification of low noise environments *"where background noise is less than 30dB(A)"* nor is there details on the application of *"an absolute level within the range of 35-40 dB(A)."* In the absence of detailed guidance from the Wind Energy Development Guidelines 2006, on what range of *35-40 dB* to use, we have referred to guidance from ETSU-R-97[3] which states...

> "*The actual value chosen for the day-time lower limit, within the range of 35-40dB(A), should depend upon a number of factors:*
>
> - *Number of dwellings in the neighbourhood of the wind farm.*
> - *The effect of noise limits on the number of kWh generated.*
> - *Duration and level of exposure."*

The proposed operational limits in $L_{A90,\ 10\ min}$ for the proposed Croaghaun Wind Farm are:

- 37.5 dB where background levels are less than 30 dB and a fixed limit of 45dB or 5dB above background whichever is the greater where background levels are greater than 30 dB for daytime periods. Further details on the derivation of this is outlined in section 7.4.2.
- A fixed limit of 43 dB L_{A90} for night-time periods.

The 2006 DoEHLG Wind Energy Development Guidelines do not provide the specific periods which are represented by daytime and night-time hours, therefore the definitions from ETSU-R-97 are taken as 07:00 to 23:00 hrs for daytime and 23:00 to 07:00 hrs for night-time.

The Draft Revised Wind Energy Development Guidelines were published on the 19th December 2019. The 2019 draft guidelines were out to public consultation until the 19th February 2020 and may be subject to further revision. The final version of revised guidelines have not yet been adopted and issued. As such, the current noise limits from the 2006 guidelines are used in this assessment. If new Guidelines are adopted prior to a decision on this application, Coillte are happy to demonstrate compliance with same as appropriate.

[3] See Page 65 of *The Assessment and rating of noise from wind farms (ETSU-R-97)*: ETSU (Energy Technology Support Unit) for more details.

The operational noise criteria include noise from wind turbines and any other ancillary noise sources such as the on-site substation transformer.

7.3.3.3 Off-site Substation Operational Noise Criteria

BS 4142:2014+A1:2019, *Methods for Rating and Assessing Industrial and Commercial Sound*, provides an assessment methodology for determining the likely effects of external sound experienced at residential dwellings due to industrial and commercial sound sources. The standard describes a method for rating noise levels based on the difference between the level of existing background sound (in absence of the industrial or commercial source) and the sound emission level of the source at a particular receiver location (known as the specific sound level). In instances where the specific noise level exhibits an identifiable or perceived character (such as tonality, impulsiveness, intermittency or any other distinguishing characteristic) then a penalty, depending on the nature of the sound, should be added to give the rating level. The difference between the background level and the rating level (rating noise level minus the background sound level) is then used to determine the impact of the sound, as shown at Table 7.2.

Table 7.2: Extract from BS 4142

Difference	Assessment
Around 10 dB or more	'…likely to be an indication of a significant adverse impact.'
Around 5 dB	'…likely to be an indication of an adverse impact, depending on the context.'
0 dB	'… this is an indication of the specific sound source having a low impact, depending on the context.'

However, it is acknowledged and stressed within the standard that the source of noise should be described and assessed both in terms of the margin above background sound and in the context of the existing sound environment, especially in instances where the existing environment may already have ambient (or residual) sound levels that are high in relation to background sound level and when existing sound is similar in character to the assessed source.

Whilst BS 4142 provides a general approach to the assessment of sound impact on residential amenity, there are no guidelines for the specific approach to be taken in particular circumstances and for acceptable criteria in terms of defining potential noise limits. In these respects, the standard is left entirely open to interpretation. However, the standard states that *'Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night'*.

The previous version of BS 4142, issued in 1997 and in which a similar statement was given, contained a clarifying note stating that *'…for the purposes of this standard, background noise levels below 30 dB and rating levels below about 35 dB are considered to be very low'*.

It is therefore considered that, in general and for urban or industrialised sound environments in particular, if the rated noise level is below 35 dB L_{Aeq} then this will offer sufficient protection against noise for neighbouring residents.

The substation is to be located in a particularly rural area. The background noise levels will vary with wind speed. However, the rated noise level of the substation is below 35 dB L_{Aeq} and this is considered very low as per BS 4142 and therefore as the rated noise level is below 35 dB L_{Aeq} this will offer sufficient protection against noise for neighbouring residents.

7.3.4 Significance of Impact

The criteria for determining the significance of impacts and the effects are set out in the EPAs 'Guidelines on the Information to be Contained in Environmental Impact Assessment Reports (Draft), August 2017'. The EPA guidelines do not quantify the impacts in decibel terms. In absence of such information, reference is made to relevant standards and guidance documents noise limits. If the predicted impact from the construction or operational phase are below the respective noise limits, it is considered that no significant effect occurs.

For this assessment, it has been assumed that dwellings have a medium to high sensitivity. Table 7.3 presents the impact significance criteria from the EPA guidelines.

Table 7.3: Impact Significance Criteria

Impact Significance	Criteria
Imperceptible	An impact capable of measurement but without noticeable consequences
Not significant	An impact which causes noticeable changes in the character of environment but without significant consequences
Slight impacts	An impact which causes noticeable changes in the character of the environment without affecting its sensitivities
Moderate impacts	An impact that alters the character of the environment in a manner that is consistent with existing and emerging trends
Significant impacts	An impact which, by its character, magnitude, duration or intensity significantly alters a sensitive aspect of the environment
Very Significant	An impact which, by its character, magnitude, duration or intensity significantly alters most of a sensitive aspect of the environment
Profound impacts	An impact which obliterates sensitive characteristics

7.3.5 Consultation Requirements

Chapter 5 of the EIAR refers to scoping consultation. Several submissions on noise were received as part of the consultation process. The submissions have informed the project design and this EIAR chapter.

7.4 Existing Environment

Baseline noise monitoring was undertaken at ten receptor locations surrounding the proposed Croaghaun Wind Farm to establish the existing background noise levels in the vicinity of the proposed project. These are some of the closest locations to the proposed project as well as representing different noise environments in the vicinity of the proposed project.

The 35 dB L_{A90} study area as described in Section 7.3.2 and Figure 7.1 was reviewed to determine receivers to be considered for noise monitoring. Permission to access the noise measurement locations was arranged by Coillte, with Fehily Timoney and Company setting up the noise monitoring equipment.

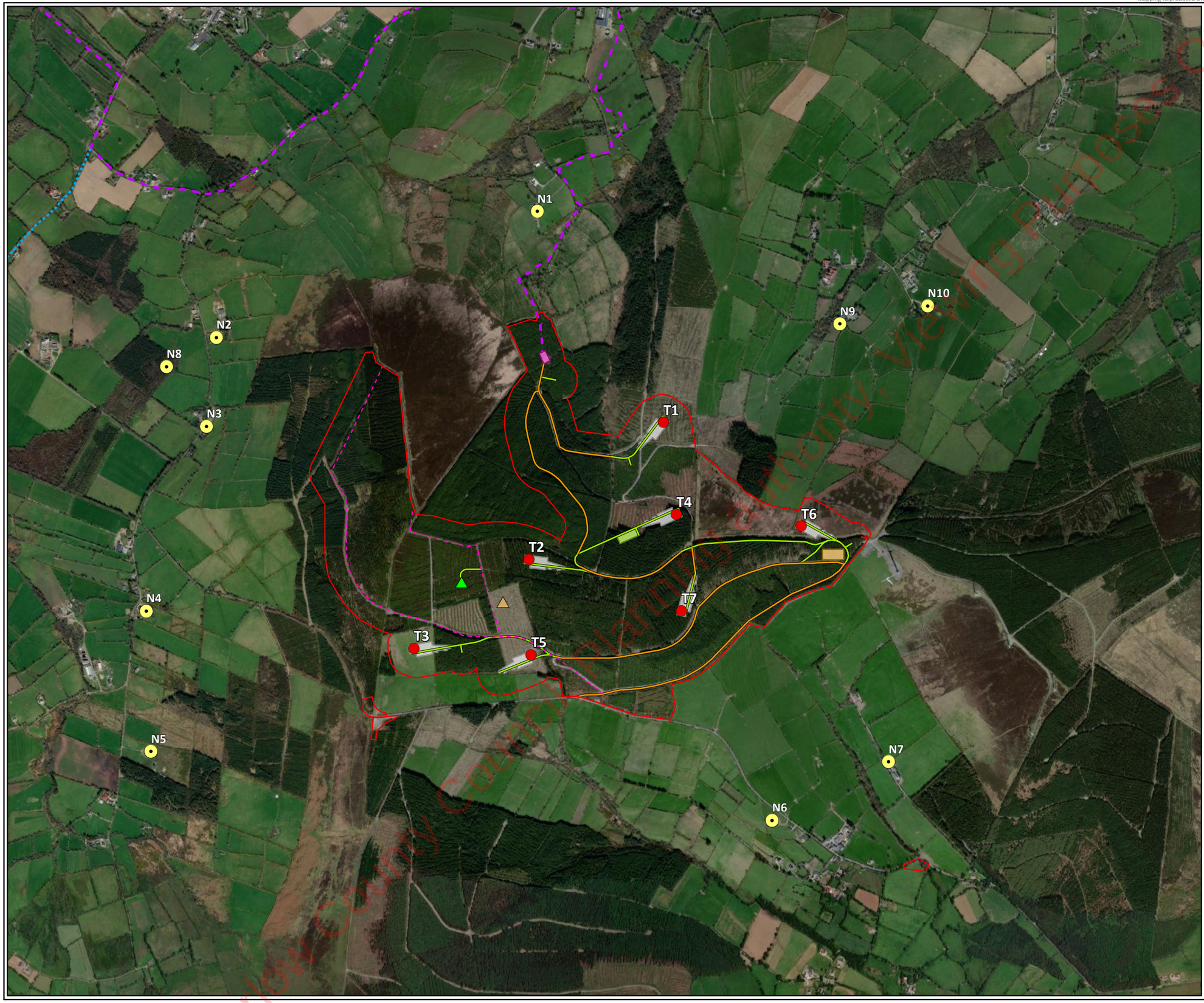
Background noise data was collected at the ten locations, shown in Figure 7.2 and details of the noise monitoring locations are presented in Table 7.4. The rationale for the selection of these monitoring locations is described in Appendix 7.1 which presents details on the baseline measurements and data analysis.

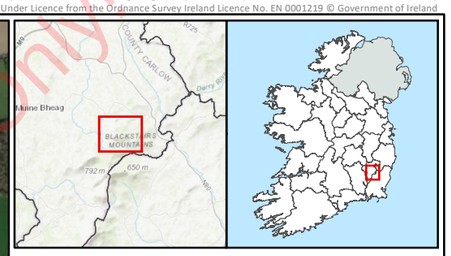
Table 7.4: Details on Noise Monitoring Locations

Location ID	Easting	Northing	Description	Photograph
N1	683970	659162	On access road to nearby farm buildings approximately 6 m from the façade dwelling.	Plate 7.1-1
N2	682464	658571	On grass edging west of the dwelling approximately 12m from the façade of the dwelling, away from trees east of dwelling and in line of sight of proposed wind farm.	Plate 7.1-2
N3	682418	658155	In courtyard by farm buildings. Located approximately 18 m from the façade of the dwelling.	Plate 7.1-3
N4	682136	657288	In field behind the dwelling approximately 20 m from the façade.	Plate 7.1-4
N5	682157	656631	In garden approximately 15 m from the façade of the dwelling.	Plate 7.1-5
N6	685072	656308	Rear of the dwelling in direction of proposed wind farm approximately 8 m from rear façade.	Plate 7.1-6
N7	685618	656582	North west of the dwelling approximately 10 m from the façade.	Plate 7.1-7
N8	682231	658434	North west boundary of garden, approximately 13 m from façade of the dwelling.	Plate 7.1-8
N9	685390	658635	South west of a dwelling in adjacent field, approximately 25m from the façade.	Plate 7.1-9

Location ID	Easting	Northing	Description	Photograph
N10	685802	658719	In garden to the east of the dwelling with a view of proposed wind farm, approximately 10 m from dwelling away from trees located in the west of the garden.	Plate 7.1-10

Path: R:\Map Production\2019\P1913\Workspace\EIAR\P1913_GIS_Fig7-2_NoiseMonitoringLocations_A3.mxd





- Noise Monitoring Locations
- Proposed Turbine Layout
- Proposed Development Boundary
- Existing 80m Met Mast
- Proposed Permanent 100m Met Mast
- Proposed Grid Connection Route
- Grid Connection Route Variant 1
- Proposed Croaghaun Loop
- Proposed Existing Road Upgrade
- Proposed New Road
- Proposed Turbine Hardstanding
- Proposed Borrow Pit
- Proposed Temporary Compound
- Proposed Substation Compound

TITLE: Noise Monitoring Locations			
PROJECT: Croaghaun Wind Farm			
FIGURE NO:	7.2		
CLIENT:	Coillte		
SCALE:	1:17500	**REVISION:**	0
DATE:	21/10/2020	**PAGE SIZE:**	A3

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7.4.1 Analysis of the Baseline Data

The raw baseline L_{A90} noise data was reviewed to determine whether there are any periods of non-consistent noise level due to equipment malfunction. If there was any data which was inconsistent, these noise level data points were removed from the raw data. The raw noise level data was then correlated with the time synchronised 10 m standardised wind speed and rainfall data. Periods of rainfall, data affected by dawn chorus and atypical data was removed from the analysis. Once the remaining data sets were found to be representative of the noise environment, they were analysed to ensure that sufficient data sets remained to provide sufficient data coverage over the necessary wind speeds. The proposed wind farm is? adjacent to Greenoge Wind Farm. In order to remove the noise contribution from Greenoge Wind Farm, directional noise predictions were undertaken and measured noise levels were corrected to remove the influence of Greenoge Wind Farm. A 'best fit' trend (not higher than a fourth order polynomial) was then derived to present the prevailing background noise level at each monitoring location. Appendix 7.1 presents the results of the data analysis. Appendix 7.2 presents equipment calibration certificates.

The prevailing daytime noise levels at the ten noise monitoring locations are presented in Table 7.5. The derived prevailing background noise polynomial curve was not extended beyond the range covered by adequate data points. Where a noise limit is required at higher wind speeds; it was restricted to the highest derived point. Details on the prevailing night-time noise levels are presented in Appendix 7.1.

Table 7.5: Prevailing Background Noise - Daytime Periods

Location	Prevailing Background Noise $L_{A90,10min}$ (dB) at Standardised 10 m Height Wind Speed (m/s)									
	3	4	5	6	7	8	9	10	11	12
N1	22.6	23.5	24.8	26.4	28.2	30.0	31.9	33.6	35.1	36.3
N2	30.4	31.4	32.6	33.8	35.3	37.0	38.9	41.1	43.6	46.5
N3	25.9	27.0	28.1	29.3	30.7	32.4	34.3	36.7	39.5	42.8
N4	27.2	28.8	30.3	31.6	32.9	34.1	35.5	36.9	38.5	40.3
N5	27.6	28.3	29.0	29.7	30.5	31.6	33.0	34.9	37.4	40.6
N6	28.5	29.7	31.2	33.0	35.0	37.3	39.6	42.1	44.6	44.6§
N7	29.7	30.8	32.2	33.8	35.6	37.5	39.3	41.0	42.5	42.5§
N8	27.6	29.0	30.7	32.5	34.4	36.2	38.0	39.5	40.7	41.6
N9	32.4*	32.4	32.4	32.4	32.6	33.2	34.1	35.5	37.6	40.4
N10	28.3	29.9	31.3	32.7	33.9	35.2	36.7	38.9	42.1	46.7

§ - noise level restricted to the highest derived point
* - noise level restricted to lowest derived point

7.4.2 Derived Wind Farm Noise Limits

The standard approach (outlined in the IoA GPG) to derivation of noise limits is to carry out background measurements at several locations representative of different noise environments around the proposed site.

As it is not usually possible to carry out measurements at every noise sensitive location (NSL), NSLs near to the measurement location are then assigned the same limits as the measurement location. The operational impact at each of the measurement locations was assessed in accordance with the IoA GPG.

The proposed project was assessed against the 'Wind Energy Development Guidelines' (2006) as these guidelines are currently in-force.

The 2006 guidelines state that a fixed limit of 43 dB L_{A90} applies during night-time periods. However, the derivation of the daytime noise limit uses the prevailing background noise data. Where low background noise levels are found, the 2006 guidelines recommend a limit of 35 to 40 dB L_{A90}. There is no further detail provided on which to determine how the appropriate noise limit be derived as stated previously above. However, the guidelines state… "An appropriate balance must be achieved between power generation and noise impact." Reference has also been made to planning permission adjacent Greenoge Wind Farm. Finally, reference is also made to ETSU-R-97 which recommends that the following three factors be considered when determining the fixed limit:

1) *Number of dwellings in neighbourhood of the wind farm.*
2) *The effect of noise limits on the kWh.*
3) *Duration and level of exposure.*

The IOA GPG states the following with respect to the ETSU-R-97 criteria… *"It can be argued that assessing these factors do not represent an acoustic consideration but ultimately a planning consideration."*

The first factor to be considered is the "*Number of dwellings in neighbourhood of the wind farm*". ETSU-R-97 describes this factor as balancing the benefits from a wind energy project with the local environment impact, "*The more dwellings that are in the vicinity of a wind farm the tighter the limits should be as the total environmental impact will be greater. Conversely if only a few dwellings are affected, then the environmental impact is less and noise limits towards the upper end of the range may be appropriate.*" The number of noise sensitive locations (includes planning permissions) within the 35dB L_{A90} study area is 51, indicating that a mid-range limit of 37.5 dB L_{A90} is appropriate.

The second factor is the effect of noise limits on the power output of the wind farm. Similarly, to the first factor, this balances the planning merit of the project against the local impact. The proposed project has 7 turbines. If the limit is lowered, then, based on the noise modelling results, curtailment would be required. Since this project is considered to have merit in assisting Ireland in meeting its renewable energy targets, the upper end of the limit range is appropriate.

The final ETSU factor relates to the duration and level of exposure. The prevailing background noise levels are described in detail in Section 7.4.1 and Appendix 7.1. The wind rose for the proposed development shows that wind speeds of 3, 4, 5, 6 and 7 m/s occur 10.2, 11.8, 12.3, 11.9 and 10.2 % of the time and on that basis a decrease in the limit towards the lower range level of 35 dB L_{A90} is appropriate.

The Wind Energy Development Guidelines (2006) states that "An appropriate balance must be achieved between power generation and noise impact." and the mid-range limit of 37.5 dB L_{A90} represents that balance.

Reference is also made to Condition 2 of Planning Reference PL11/280 for a single turbine at Greenoge Wind Farm. The planning condition text effectively paraphrases the text from the Wind Energy Development Guidelines 2006.

No guidance is provided on an absolute noise level for the environments where background noise is less than 30 dB LA90, instead it states… *"the wind energy development noise shall be limited to an absolute level with the 35 – 40 dB L_{A90}".*

Given the information above, it is recommended that a fixed limit of 37.5 dB L_{A90} for low background noise conditions should apply for the proposed project. It represents an appropriate balance between power generation and noise impact.

Table 7.6: Derived Noise Limits

Location	Period	Prevailing Background Noise $L_{A90,10min}$ (dB) at 10 m Standardised wind speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
N1	Daytime	37.5	37.5	37.5	37.5	37.5	37.5	45.0	45.0	45.0	45.0
	Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
N2	Daytime	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1	48.6	51.5
	Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
N3	Daytime	37.5	37.5	37.5	37.5	45.0	45.0	45.0	45.0	45.0	47.8
	Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
N4	Daytime	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.3
	Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
N5	Daytime	37.5	37.5	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.6
	Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
N6	Daytime	37.5	37.5	45.0	45.0	45.0	45.0	45.0	47.1	49.6	49.6
	Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
N7	Daytime	37.5	45.0	45.0	45.0	45.0	45.0	45.0	46.0	47.5	47.5
	Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
N8	Daytime	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.0	45.7	46.6
	Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
N9	Daytime	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.4
	Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
N10	Daytime	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.0	47.1	51.7
	Night-time	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

7.5 Potential Impacts

7.5.1 Do Nothing Scenario

Under the Do-Nothing scenario, the proposed project is not constructed or operated. The noise environment in the vicinity of the proposed wind farm site will remain largely unchanged. The noise environment adjacent to substation at Kellistown will change due to the contented Kellistown East Energy Storage Facility.

7.5.2 Potential Impacts during Construction

Noise predictions were undertaken to determine the likely impact during the construction works. BS 5228-1:2009+A1:2014 sets out sound power levels and L_{Aeq} noise levels of plant items normally encountered on construction sites, which in turn enables the prediction of noise levels at selected locations. Construction noise modelling is based on the details presented in Section 3.6 of this EIAR and the Construction and Environmental Management Plan as well as a review of other chapters in the EIAR. Noise modelling was carried out using guidance and plant noise data from BS 5228:2009+A1:2014. The ground cover is predominately acoustically soft (G=1)[4]. The noise model assumes that the ground cover is a mix between acoustically hard and soft ground with a ground cover of G=0.75 to allow for pockets of acoustically hard ground. Percentage on time[5] for plant is outlined for each of the plant items used during construction.

The construction noise model assessed several tasks with the potential to generate noise. These tasks included: deliveries and/or removal of material to and from site, felling, preparation of access roads, excavation of material from a borrow pit, preparation of hardstands and drainage, excavation of foundations, pouring of foundations and installation of wind turbines. The of-site works assessed included: works associated with grid connection, directional drilling at 9 no. locations along the proposed grid route, verge widening works and installation of a temporary steel bridge and construction of the off-site substation at Kellistown.

Site Traffic

Detailed information on construction traffic is presented in Chapter 13. To summarise, additional light goods vehicles travelling to and from the site during the construction phase would be expected to peak during the morning (arrival of contractors at the site) and evening (departure of contractors from the site) and are envisaged not to be a continuous source of noise emissions from the site during a typical working day. The noise impact from construction personnel movements to and from the site is expected to be low.

All deliveries of turbine components to the site will only be by way of the proposed transport route outlined in Chapter 13. The most intensive period of the works programme will be Month 7 (see Figure 13.3 in Chapter 13 Traffic and Transportation) when multiple construction activities take place concurrently.. The noise impact for construction works traffic will be mitigated by generally restricting movements along access routes to the standard working hours and exclude Sundays, unless specifically agreed otherwise. For example, during turbine erection and foundation pours, an extension to the working day may be required, i.e. 05:00 to 21:00, but this would be necessary only on a relatively small number of occasions.

[4] G denotes the ground cover from an acoustic perspective. G=0 refers to acoustically hard or reflective surface and G=1 refers to acoustic soft or absorptive surface.

[5] Percentage on-time refers to the percentage of the assessment period for which the activity takes place.

If turbine deliveries are required at night it will be subject to agreement with the relevant planning authority and it would be ensured that vehicles on local roads do not wait outside residential properties with their engines idling, and that the local residents will be informed of any activities likely to occur outside of normal working hours.

The most intensive period of the works programme will be Month 7 when multiple construction activities take place concurrently. These activities include turbine hard standing and foundation construction, turbine installation, on-site and off-site substation construction, grid connection cable works and internal electrical works. The predicted cumulative noise at all noise sensitive locations in the vicinity of the proposed project will be less than 50 dB $L_{Aeq,1hr}$ at the nearest occupied dwelling which is below the construction noise limit of 65 dB $L_{Aeq,1hr}$.

Tree Felling

Much of the proposed site comprises commercial coniferous forestry. Three no. turbines (T2, T4 and T7) are located within forestry and consequently tree felling will be required as part of the project. It is proposed that tree felling will occur over two months at the beginning of the project. Table 7.7 presents the predicted noise levels from this activity at the nearest dwelling R3 approximately 1160 m from the proposed felling at turbine T4. Assuming all plant is operating, the predicted cumulative noise at R3 is 40.5 dB $L_{Aeq,1hr}$. Therefore, the predicted noise at the nearest noise sensitive location is below the daytime noise limit of 65 dB $L_{Aeq,1hr}$. The noise associated with the felling activity is expected to have a slight impact and temporary in duration.

Table 7.7: Tree Felling – Likely Plant and Predicted Noise Levels

Plant	BS 5228 Ref.	Activity	Percentage on-time (%)	Predicted Noise Level at R3
Harvester §	C2.5	Harvesting trees	80	37.7
Forwarder µ	C4.53	Moving felled trees	80	37.1
Lorry *	C11.9	Transporting timber and brash off site	1 two-way trip per hour	24.4
Cumulative				40.5
* Drive-by maximum sound pressure level § - Excavator BS 5228 Ref C2.5 µ - Lorry with lifting boom – C4.53				

Borrow Pit

There is one borrow pit proposed at the centre of the site on site, near Turbine 4. The location of the proposed borrow pit is shown in Figure 3-1. The proposed borrow pit is underlain by the Maulin Formation which is classified by the GSI as being of 'Low' potential for crushed rock aggregate.

However, as outlined in Section 9.3.6 intrusive site investigations undertaken at the proposed borrow pit location identified overburden deposits comprising silty Clay, weathered and intact Bedrock suitable for use as general fill for the construction of the proposed project.

There will be no blasting required in the borrow pit. It is expected that a rock breaker and crusher will be required at the borrow pit. Table 7.8 presents the predicted noise levels from this activity at the nearest dwelling R3 approximately 1400m from the proposed borrow pit. Assuming all plant is operating at the borrow pit, the predicted cumulative noise at R3 is 37.3 dB $L_{Aeq,1hr}$. Therefore, the predicted noise at the nearest noise sensitive location is below the daytime noise limit of 65 dB $L_{Aeq,1hr}$. The noise associated with the borrow pit activity is expected to have a slight impact and temporary in duration.

Table 7.8: Borrow Pit – Likely Plant and Predicted Noise Levels

Plant	BS 5228 Ref.	Activity	Percentage on-time (%)	Predicted Noise Level at R3
Diesel Pump	C4.88	Pump water	100	-
Tracked Hydraulic Excavator (37t)	C10.1	Face shovel extracting/ loading dump trucks	80	18.3
Rock Breaker	C9.12	Rock breaking	50	18.4
Crusher	C1.14	Crushing material	100	20.8
Tracked Excavator (21t)	C4.65	Trenching	80	4.1
Dozer (41t)	C2.10	Ground Excavation/Earthworks	80	19.6
Articulated Dump Truck (23t) *	C2.33	Distribution of Material	Maximum 50 two-way trips per day	37
Cumulative				37.3
* - Drive-by maximum sound level				

Preparation of Access roads, Hardstands and Drainage

Table 7.9 presents the predicted noise levels from this activity at the nearest dwelling R1 approximately 670 m from substation. Assuming all construction activities required for the preparation of the hardstanding occur simultaneously, the predicted noise level from the construction activities is 42.3 dB $L_{Aeq,1hr}$ which is below the 65dB $L_{Aeq,1hr}$ noise limit. The preparation of access roads, hardstands and drainage are expected to have a slight impact and temporary in duration.

Table 7.9: Preparation of Access roads, Hardstands and Drainage - Likely Plant and Predicted Levels

Plant	BS 5228 Ref.	Activity	Percentage on-time (%)	Predicted Noise Level at R1
Tracked Excavator (25t)	C2.19	Ground excavation/ earthworks	80	37.2
Articulated Dump Truck (23t)	C2.32	Tipping Fill	20	27.7
Dozer (14t)	C5.12	Spreading chipping/fill	80	36.4
Vibratory roller (3t)	C5.27	Rolling and Compaction	80	26.3
Excavator (21t)	C4.65	Trench for drainage	80	31
Articulated Dump Truck *	C2.33	Delivery of Material	Maximum 50 two-way trips per day	37
Cumulative				42.3
* - Drive-by maximum sound level				

Preparation of Wind Turbine Foundations

Table 7.10 presents the likely plant required for the preparation of wind turbine foundations. Also presented is the predicted noise levels from the nearest receptor R3 over 950 m away. Assuming all construction activities required for the preparation of the turbine foundations occur simultaneously, the predicted noise level from the construction activities is 41.8 dB $L_{Aeq,1hr}$. The predicted noise level is below the 65dB $L_{Aeq,1hr}$ noise limit. The construction works associated with the preparation of the turbine foundations are expected to have a slight impact and temporary in duration.

Table 7.10: Preparation of Wind Turbine Foundations - Likely Plant and Predicted Levels

Plant	BS 5228 Ref.	Activity	Percentage on-time (%)	Predicted Noise Level at R3
Tracked Excavator (25t)	C2.19	Ground excavation/earthworks	80	33.6
Excavator (23t)	C10.8	Loading sand / soil	80	35.4
Diesel Pump	C4.88	Pump water	100	25
Excavator mounted rock breaker (23t)	C9.12	Breaking Rock	50	37.2

Plant	BS 5228 Ref.	Activity	Percentage on-time (%)	Predicted Noise Level at R3
Mobile telescopic crane	C4.41	Lifting reinforcing steel	80	28.4
Concrete mixer truck & concrete pump	C4.32	Concrete mixer truck + truck mounted concrete pump + boom arm	100	34.3
Lorry*	C11.9	Delivery and removal of material	Maximum 32 two-way trips per day	26.8
Cumulative				41.8
* - Drive-by maximum sound level				

Installation of Wind Turbines

Turbine components will be delivered to site and mobile telescopic cranes will lift the turbine components into place. A worst case of the two cranes lifting turbine components 100% of the time is assumed along with delivery of turbine components. The predicted noise levels are presented in Table 7.11. The predicted cumulative noise level at receptor R3 is 32.7 dB $L_{Aeq,1hr}$. The predicted noise levels are below the 65 dB $L_{Aeq,1hr}$ noise limit. The construction works associated with the installation of the wind turbines are expected to have be not significant and temporary in duration.

Table 7.11: Installation of Wind Turbines - Likely Plant and Predicted Levels

Plant	BS 5228 Ref.	Activity	Percentage on-time (%)	Predicted Noise Level at R3
Mobile telescopic crane (x2)	C4.41	Lifting turbine components	100	31.4
Lorry *	C11.9	Delivery of Turbine Components	Maximum 32 two-way trips per day	26.8
Cumulative				32.7
* - Drive-by maximum sound level				

Construction of Substation

The construction of two substation buildings will occur during the construction phase of the proposed project. One substation building is on site and the other substation building is at Kellistown. The construction works will be progressed in several phases:

- Site clearance and Preparation
- Preparation and pouring of foundations and floor areas

- Preparation of hardstanding areas
- Erection of blockwork/ installation concrete slabs
- General Construction including installation of electrical and mechanical plant

Table 7.12 presents the likely plant required for the different construction phases of the proposed buildings to be constructed on site. The nearest dwelling (R1) from the on-site substation location will be approximately 670 m away from the substation area. The cumulative predicted noise levels for the worst combination of plant (Site Clearance and Preparation) is predicted to be 45 dB $L_{Aeq,1hr}$ at the nearest occupied dwelling which is below the construction noise limit of 65 dB $L_{Aeq,1hr}$. The works associated with the construction of the substation are expected to have a slight impact and temporary in duration.

Table 7.12: Construction of Substation - Likely Plant and Predicted Levels

Phase	Plant	BS 5228 Ref.	Activity	Percentage on-time (%)	Predicted Noise Level at R1
Site Clearance and Preparation	Tracked excavator (22t)	C2.3	Clearing Site	80	37.7
	Dozer (11t)	C2.12	Ground excavation/ earthworks	80	40.4
	Loading Lorry	C10.8	Loading Sand to Lorry	80	39.9
	Tracked Excavator (25t)	C2.19	Ground excavation/ earthworks	80	37.2
	Cumulative				45.0
Preparation and pouring of Foundations	Concrete mixer truck + truck mounted concrete pump + boom arm	C4.32	Concrete pumping	100	38.5
	Lorry*	C11.9	Delivery of material	Maximum of 32 two-way trips per day	37.7
	Cumulative				41.1
Preparation of hardstanding areas	Articulated Dump Truck (23t)	C2.33	Delivery/Removal of Material	Maximum of 50 two-way trips per day	37
	Tracked Excavator (25t)	C2.19	Ground excavation/ earthworks	80	37.2
	Articulated Dump Truck (23t)	C2.32	Tipping Fill	20	27.6
	Dozer (14t)	C5.12	Spreading chipping/fill	80	36.4
	Vibratory roller (3t)	C5.27	Rolling and Compaction	80	26.3

Phase	Plant	BS 5228 Ref.	Activity	Percentage on-time (%)	Predicted Noise Level at R1
	Lorry*	C11.9	Delivery of material	Maximum of 32 two-way trips per day	37.7
	Cumulative				43.3
Erection of blockwork/ installation concrete slabs	Mobile telescopic crane (80t)	C4.39	Lifting concrete slabs	80	36.4
	Lorry* (32t)	C11.9	Delivery of material	Maximum of 32 two-way trips per day	37.7
	Cumulative				40.1
General Construction including installation of electrical and mechanical plant	Generator	C4.84	Power for site cabins	100	34.3
	Lifting Platform (x2)	C.57	Lifting Personnel	80	29.8
	Telescopic handler	C4.54	Lifting Plant	80	38.4
	Angle grinder (grinding steel)	C4.93	Miscellaneous	80	40.4
	Cumulative				43.3
* Drive-by maximum sound level					

The most intensive period of the works programme will be Month 7 when multiple construction activities take place concurrently. These activities include turbine hard standing and foundation construction, turbine installation, on-site and off-site substation construction, grid connection cable works and internal electrical works. The predicted cumulative noise at all noise sensitive locations in the vicinity of the proposed project will be less than 50 dB $L_{Aeq,1hr}$ at the nearest occupied dwelling which is below the construction noise limit of 65 dB $L_{Aeq,1hr}$.

Works will also be required in proximity to the existing substation at Kellistown to accommodate the proposed project. The works will allow the voltage from the wind farm grid connection to be 'stepped up' to 110kV. The proposed substation compound will be self-contained and positioned in a neighbouring field to that of the existing Kellis substation as shown in Figure 3.4 and accompanying planning drawings. There are two options being considered. The location closest to dwellings has been assessed as this represents a worst-case scenario.

Table 7.13 presents the likely plant required for the different construction phases of the proposed buildings to be constructed on site. The nearest dwelling is approximately 225 m away from the proposed off-site substation. The cumulative predicted noise levels for the worst combination of plant (Site Clearance and Preparation) is predicted to be 56.5 dB $L_{Aeq,1hr}$ at the nearest occupied dwelling which is below the construction noise limit of 65 dB $L_{Aeq,1hr}$. The works associated with the construction of the substation are expected to have a moderate impact and temporary in duration.

Table 7.13: Construction of Substation - Likely Plant and Predicted Levels

Phase	Plant	BS 5228 Ref.	Activity	Percentage on-time (%)	Predicted Noise Level at Nearest NSL
Site Clearance and Preparation	Tracked excavator (22t)	C2.3	Clearing Site	80	49.2
	Dozer (11t)	C2.12	Ground excavation/ earthworks	80	51.8
	Loading Lorry	C10.8	Loading Sand to Lorry	80	51.4
	Tracked Excavator (25t)	C2.19	Ground excavation/ earthworks	80	48.8
	Cumulative				56.5
Preparation and pouring of Foundations	Concrete mixer truck + truck mounted concrete pump + boom arm	C4.32	Concrete pumping	100	50.0
	Lorry*	C11.9	Delivery of material	Maximum of 32 trips per day	30.4
	Cumulative				50.0
Preparation of hardstanding areas	Tracked Excavator (25t)	C2.19	Ground excavation/ earthworks	80	48.8
	Articulated Dump Truck (23t)	C2.32	Tipping Fill	20	39.2
	Dozer (14t)	C5.12	Spreading chipping/fill	80	47.9
	Vibratory roller (3t)	C5.27	Rolling and Compaction	80	37.9
	Lorry*	C11.9	Delivery of material	Maximum of 32 trips per day	30.4
	Cumulative				51.8
Erection of blockwork/ installation concrete slabs	Mobile telescopic crane (80t)	C4.39	Lifting concrete slabs	80	47.9
	Lorry* (32t)	C11.9	Delivery of material	Maximum of 32 trips per day	30.4
	Cumulative				48.0
General Construction including installation of electrical and mechanical plant	Generator	C4.84	Power for site cabins	100	45.9
	Lifting Platform (x2)	C.57	Lifting Personnel	80	41.4
	Telescopic handler	C4.54	Lifting Plant	80	49.8
	Angle grinder (grinding steel)	C4.93	Miscellaneous	80	51.9
	Cumulative				54.8
* Drive-by maximum sound level					

Grid Connection Works

It is proposed to construct 1 no. on-site electricity substation within the proposed wind farm site. Each turbine will be connected to the on-site electricity substation via underground electricity cables. The cable route will follow the proposed access tracks between each turbine. The on-site substation is will be connected via a grid connection cable to a substation at Kellistown. The cable will be installed predominantly along the public road and shall feature horizontal directional drilling at up to 9 no. locations to cross existing watercourses.

The grid connection works will be carried out over a 10-month period and 'rolling road closures' will be implemented, whereby the site will progress each day along a road, which will have the effect of reducing the impact for residents. The likely plant required during the construction works are presented in Table 7.14.

Table 7.14: Grid Connection Works – Likely Plant and Predicted Noise Levels

Plant	Activity	Percentage on-time (%)	A-Weighted Sound Pressure Level, L_{Aeq}, dB			
			10m	25m	50m	100m
Road sweeper (C4.90)	Sweeping and dust suppression	10	49.5	41.6	35.6	29.6
Mini excavator with hydraulic breaker (C5.2)	Breaking Road Surface	25	78.9	71.4	65.5	59.5
Vibratory roller (C5.27)	Rolling and Compaction	50	66.3	58.6	52.6	46.6
Wheeled excavator (C5.34)	Trenching	50	69.9	62	56	50
Hand-held circular saw (petrol) (C5.36)	Cutting Concrete Slabs	10	79	71.6	65.6	59.6
Dump truck (tipping fill) (C2.30)	Tipping Fill	10	71.8	64.1	58.1	52.1
Vibratory plate (petrol) (C2.41)	Compaction	10	72.7	65.1	59.1	53.1
Directional drilling	Drilling	100	-	62.7	52.8 @ 70m	49.3

Table 7.14 also presents predicted noise level for a range of construction activities at distances of 10 m, 25 m, 50 m and 100 m from the works. The noise levels presented are predicted maximum expected levels and are expected to occur for only short periods of time at a very limited number of dwellings. There are four dwellings within 10 m of the grid connection works, 59 dwellings between 25 – 50 m, 68 dwellings between 25 – 50 m and 28 dwellings between 50 - 100 m.

Directional drilling is required at up to 9 no. of locations, the nearest dwellings have been identified the closest distance being 25 m. The other dwellings are at least 70m away and at some directional drilling locations directional drilling is up to 345 m away. The predicted noise from this activity is also presented in Table 7.13. The predicted noise levels are below the noise limits.

In some instances, the maximum predicted noise levels from grid connection works may be above the noise limit of 65 dB $L_{Aeq,1hr}$. However, these elevated noise levels will only occur for short durations at a limited number of dwellings. Given the nature of the grid connection works, construction activities will not occur over an extended period at any one location.

Mitigation measures will be employed to reduce any potential impacts. Mitigation measures are discussed in Section 7.6.1. With mitigation measures, there is potential for temporary elevated noise levels due to the grid connection works. However, these works will be for a short duration at a particular property (i.e. typically less than 3 days) and where the works are to occur over an extended period, a temporary barrier or screen will be used to reduce noise level below the noise limit. The works are expected to have a significant temporary impact.

Temporary Bridge Structure

It is proposed to cross the Kilbranish North River (POI43) using the existing road bridge as described in Chapter 3 of this EIAR. A temporary bridge crossing is also proposed for oversized vehicles. It will be located directly south of the existing bridge structure. The noise impact associated with its construction has been assessed. Table 7.15 presents the likely plant required for the construction of the temporary bridge. Also presented is the predicted noise levels at the nearest dwelling approximately 200 m from the works. The cumulative predicted noise levels assuming all activity occurs simultaneously is predicted to be 55.2 dB $L_{Aeq,1hr}$ at the nearest occupied dwelling which is below the construction noise limit of 65 dB $L_{Aeq,1hr}$. The works associated with the construction of the temporary bridge is expected to have a slight to moderate impact and temporary in duration.

Table 7.15: Temporary Bridge Structure - Likely Plant and Predicted Levels

Plant	BS 5228 Ref.	Activity	Percentage on-time (%)	Predicted Noise Level at Nearest NSL 200 m away
Tracked Excavator (25t)	C2.19	Ground excavation/ earthworks	80	49.9
Articulated Dump Truck (23t)	C2.32	Tipping Fill	20	40.4
Excavator (23t)	C10.8	Loading sand / soil	80	52.7
Vibratory roller (3t)	C5.27	Rolling and Compaction	80	40
Mobile telescopic crane	C4.41	Lifting turbine components	100	44.5
Cumulative				55.2

7.5.3 Potential Impacts during Operation

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

Only the worst-case downwind condition has been considered in this assessment, that is – for wind blowing from the proposed turbines towards the nearby houses. When the wind is blowing in the opposite direction noise levels may be significantly lower, especially where there is any shielding between the turbines and the houses.

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

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

These factors are discussed in detail below.

The predicted octave band levels from the turbine are summed together to give the overall 'A' weighted predicted sound level.

L_W - Source Sound Power Level

The sound power level of a noise source is normally expressed in dB re:1pW. Noise predictions are based on sound power levels provided for the Siemens Gamesa SG 5.0-132 with Trailing Edge Serrations (TES). Sound Power Level data is presented in Appendix 7.4. Further details on the wind turbine are provided later in this section.

D – Directivity Factor

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

A_{geo} – Geometrical Divergence

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

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

where, d = distance from the turbine

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

A_{atm} - Atmospheric Absorption

The atmospheric absorption accounts for the frequency dependant linear attenuation with distance of sound power over the frequency spectrum according to:

$A_{atm} = d \times \alpha$
where, α = the atmospheric absorption coefficient of the relevant frequency band

Published values of 'α' from ISO9613 Part 1[6] have been used, corresponding to a temperature of 10^0C and a relative humidity of 70%, the values specified in the IoA GPG, which give relatively low levels of atmospheric attenuation, and subsequently conservative noise predictions as given in Table 7.16.

Table 7.16: Atmospheric Octave Band Attenuation coefficients, dB/m

Octave Band Centre Frequency (Hz)							
63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
0.00012	0.00041	0.00104	0.00193	0.00366	0.00966	0.03280	0.11700

A_{gr} - Ground Effect

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

The ground conditions are described according to a variable G which varies between 0 for 'hard' ground (includes paving, water, ice, concrete and any sites with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation). The IoA GPG states that use of G = 0.5 and a receptor height of 4 m should be used to predict the resultant turbine noise level at dwellings neighbouring a proposed development provided that an appropriate allowance for measurement uncertainty is accounted for within the stated source noise levels. Therefore, predictions in this report are based on G = 0.5 with a receptor height of 4 m and, due to the inclusion of the assumed uncertainty (see 'Overview of Input Datasets' for more details) within the source noise levels, these predictions are considered to be worst case.

A_{bar} - Barrier Attenuation

The effect of any barrier between the noise source and the receiver position is that noise will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the noise. The barrier attenuations predicted by the ISO 9613 model have, however, been shown to be significantly greater than that measured in practice under downwind conditions.

[6] ISO 9613-1, Acoustics - Attenuation of sound during propagation outdoors, Part 1: Method of calculation of the attenuation of sound by atmospheric absorption, International Organization for Standardization, 1992

The results of a study of propagation of noise from wind farm sites carried out for ETSU concludes that an attenuation of just 2 dB(A) should be allowed where the direct line of site between the source and receiver is just interrupted and that 10 dB(A) should be allowed where a barrier lies within 5 m of a receiver and provides a significant interruption to the line of site.

The IoA GPG states that *'Topographic screening effects of the terrain (ISO 9613-2, Equation 2) should be limited to a reduction of no more than 2 dB, and then only if there is no direct line of sight between the highest point on the turbine rotor and the receiver location'*. As a conservative approach, this has not been accounted for in the noise model predictions.

A_{misc} – Miscellaneous Other Effects

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

The site topography was also analysed to determine if there is a valley correction (+3 dB) for concave ground profile, or where the ground falls away significantly, between the turbine and the receiver location. The IoA guidelines provide a criterion of application and it was determined that a valley correction is applicable for some turbine – noise sensitive location combinations for this site and +3 dB correction has been added when the IoA criterion is met.

The valley correction for each wind turbine / noise sensitive location combination is presented in Appendix 7.5.

Predicted Noise Levels

The predicted turbine noise L_{Aeq} has been adjusted by subtracting 2 dB to give the equivalent L_{A90} as suggested in the IoA GPG.

Overview of Input Datasets

In order to calculate the noise levels at noise sensitive locations, an accurate representation of the source and receiver positions (See Appendix 7.3 for details) was necessary for the prediction modelling. The turbine locations are presented in Table 3.1 in Section 3.5.3 of Chapter 3 of this EIAR and noise sensitive locations are presented in Appendix 7.3. The closest dwellings are at least 950 m from the nearest turbine. For the purpose of this assessment a 20 m offset from the building façade was used for the calculation of predicted operational noise impacts. For the closest dwellings to the proposed project, where the curtilage of a dwelling was greater than 20 m from the façade the curtilage boundary was used.

The actual turbines to be installed at the proposed wind farm will be the subject of a competitive tender process and may include turbines not amongst the turbine models currently available. Regardless of the make or model of the turbine eventually selected for installation on site, the noise it will give rise to will be of no greater significance than that used for the purposes of this assessment to ensure that the findings remain valid.

For the purposes of this assessment, noise predictions are based on sound power levels provided for the Siemens Gamesa SG 5.0-132. The Siemens Gamesa SG 5.0-132 is the worst performing turbine from a noise perspective of several turbines assessed that meet the dimensional envelope of the proposed project.

The actual turbines to be installed at the proposed wind farm will be the subject of a competitive tender process and may include turbines not amongst the turbine models currently available. Regardless of the make or model of the turbine eventually selected for installation on site, the noise it will give rise to will be of no greater significance than that used for the purposes of this assessment to ensure that the findings remain valid.

The sound power level and octave band values for the turbine are based on the noise levels provided by the manufacturer (Document ref: Standard Acoustic Emission, SG 5.0-132, Rev. 1). The sound power levels at standardised 10 m height wind speeds are presented in Table 7.17 and octave band data in dB(A) is presented in Table 7.18. The manufacturer's data presented in terms of hub height is presented in Appendix 7.4.

Table 7.17: Wind Turbine (Siemens Gamesa SG 5.0-132) Sound Power Levels, dB L_{WA}

Turbine	Standardised 10 m Height Wind Speed (m/s)						
	3	4	5	6	7	8	9
SG 5.0 132 (Normal Operation)	92.8	97.2	101.6	105.5	106.2	106.2	106.2

Table 7.18: Wind Turbine (Siemens Gamesa SG 5.0-132) Octave Band Noise Levels, dB(A) for a range of Standardised 10 m Height Wind Speeds

10 m Standardised wind speed (m/s)	Octave Band Level Centre Frequency in Hz								
	31.5	63	125	250	500	1000	2000	4000	8000
3	63.4	75.1	81.9	84.8	85.2	87.1	86.7	80.6	68.6
4	67.9	79.5	86.2	89.1	89.5	91.4	91.0	84.9	72.7
5	72.3	84.1	90.6	93.6	94.0	95.8	95.5	89.3	77.3
6	76.8	87.7	94.6	97.5	97.9	99.7	99.4	93.3	81.4
7	78.3	89.1	95.4	98.5	98.7	100.4	99.8	93.8	81.5
8	77.2	88.4	95.1	98.7	99.5	100.7	98.8	92.7	82.8
9	77.4	88.2	95.0	98.6	99.7	100.8	98.5	92.2	83.0

The IoA GPG states that it should be ensured that a margin of uncertainty is included within source wind turbine noise data used in noise predictions. A 2 dB correction is added to the sound power level to account for a margin of uncertainty.

It is possible to run all turbine models in noise reduced modes of operation (NROs) whereby the noise level is lessened by reducing the rotational speed of the turbines, with a resultant loss of electrical energy production.

This assessment includes the cumulative noise from all on-site noise sources from the proposed project. In addition to the noise from wind turbines, noise will be produced by the transformers located in the substations. The noise level is likely to depend on the load on the transformer which is dependent on the wind speed (as the wind turbines producing more energy in high wind speeds).

Predictions have been carried out based on an example ABB transformer. The sound pressure level of ≤50 dB(A) at 2 m. Using the dimensions of the transformer, the sound power level was calculated to be 76 dB(A). The octave band profile for the transformer has been sourced from 'An Introduction to Sound Level Data for Mechanical and Electrical Equipment' published by CED Engineering. The A-weighted octave band data is presented in Table 7.19.

Table 7.19: Octave Band Sound Power Level Data

Equipment	A-weighted Octave Band Centre Frequency (Hz)									Overall L_{WA}
	31.5	63	125	250	500	1k	2k	4k	8k	
Transformer Ω	64	70	72	67	67	61	56	51	44	**76**
Ω - Manufacturer's datasheet provided information on overall sound power levels. Octave band data was sourced from 'An Introduction to Sound Level Data for Mechanical and Electrical Equipment' CED Engineering										

Noise predictions have also been carried out using International Standard ISO 9613, *Acoustics – Attenuation of Sound during Propagation Outdoors*. A worst case with plant producing their highest noise emissions has been assumed. Wind turbine noise predictions are presented in terms of the L_{A90} noise indicator. However, the on-site substation transformer is typically assessed in terms of the L_{Aeq} noise indicator. The noise limits for the proposed project are in terms of L_{A90}. For the purpose of assessing the cumulative impact from all noise sources on site, it has been assumed that noise from the on-site substation transformer other noise sources is a constant level and the L_{Aeq} noise level is equal to the L_{A90} noise level. This is a conservative approach, but it facilitates the calculation of cumulative noise. Predicted results are presented in the next section.

7.5.3.1 Potential Operational Impact – Predicted Noise Levels

Noise predictions were performed for the 7-wind turbine layout modelling Siemens Gamesa SG 5.0-132 wind turbines for a range of standardised 10m height wind speeds from 3 m/s up to 9 m/s (to cut-out[7]). Receptors within the 35 dB L_{A90} noise contour of the turbines were modelled. A number of the receptors were identified as farm buildings or unoccupied derelict buildings and these have not been considered as part of the impact assessment and were not assessed against the derived daytime and night-time noise levels. Predicted noise levels from other on-site noise sources were also modelled and cumulative noise from all on-site noise sources from the proposed project are assessed against the derived noise limits.

Table 7.20 presents predicted noise levels adjacent to the 10 noise monitoring locations. The locations presented represent the dwellings with the highest noise levels for each of the 10 monitoring locations. The predicted noise levels at all receptor locations are presented in Appendix 7.5. Note: the predicted noise levels are for a worst-case scenario with noise sensitive receptors downwind of the proposed wind farm.

[7] Noise emissions from the wind turbines plateau at wind speeds above 9 m/s

In practice, receptor locations will not be downwind of all noise sources and the actual noise levels will be lower than those presented in Table 7.20 and Appendix 7.5.

Table 7.120 also presents derived daytime and night-time noise limits at each of these locations. The predicted noise levels from the proposed project are below the daytime and night-time noise levels. However, at some receptor locations, a new source of noise will be introduced into the soundscape and it is expected that there will be a long-term moderate significance of impact on the closest dwellings to the proposed wind farm.

In order to protect residents, the cumulative impact from other nearby operational and consented wind farm developments must also be considered and this is assessed in Section 7.5.5.

Table 7.20: Assessment of Predicted L_{A90} Noise Levels for Croaghaun Wind Farm against Noise Limits

Receptor ID	Description	Predicted L_{A90} Sound Pressure Level at 10m Standardised Wind Speed, dB									
		3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
H1	Predicted Level	23.3	27.4	31.9	35.7	36.6	36.8	36.9	36.9	36.9	36.9
	Daytime limit	37.5	37.5	37.5	37.5	37.5	37.5	45.0	45.0	45.0	45.0
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H3	Predicted Level	25.1	29.4	33.8	37.7	38.6	38.8	38.8	38.8	38.8	38.8
	Daytime limit	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.4
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H19	Predicted Level	23.3	27.6	32.1	36.0	36.9	37.1	37.1	37.1	37.1	37.1
	Daytime limit	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.0	47.1	51.7
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H21	Predicted Level	20.7	25.0	29.5	33.4	34.2	34.5	34.5	34.5	34.5	34.5
	Daytime limit	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.3
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H39	Predicted Level	24.2	28.5	33.0	36.8	37.7	37.9	37.9	37.9	37.9	37.9
	Daytime limit	37.5	45.0	45.0	45.0	45.0	45.0	45.0	46.0	47.5	47.5

Receptor ID	Description	Predicted L_{A90} Sound Pressure Level at 10m Standardised Wind Speed, dB									
		3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H46	Predicted Level	20.1	24.4	28.9	32.8	33.7	33.9	33.9	33.9	33.9	33.9
	Daytime limit	37.5	37.5	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.6
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H47	Predicted Level	19.7	24.0	28.4	32.3	33.2	33.4	33.4	33.4	33.4	33.4
	Daytime limit	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1	48.6	51.5
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H52	Predicted Level	21.2	25.5	30.0	33.9	34.8	35.0	35.0	35.0	35.0	35.0
	Daytime limit	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.0	45.7	46.6
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H120	Predicted Level	24.3	28.6	33.0	36.9	37.8	38.0	38.0	38.0	38.0	38.0
	Daytime limit	37.5	37.5	45.0	45.0	45.0	45.0	45.0	47.1	49.6	49.6
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H175	Predicted Level	20.8	25.1	29.5	33.4	34.3	34.5	34.6	34.6	34.6	34.6

Receptor ID	Description	Predicted L_{A90} Sound Pressure Level at 10m Standardised Wind Speed, dB									
		3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
	Daytime limit	37.5	37.5	37.5	37.5	45.0	45.0	45.0	45.0	45.0	47.8
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-

7.5.3.2 Off-Site Substation

Operational noise associated with the proposed substation at Kellistown has been assessed with reference to BS 4142:2014+A1:2019 *Methods for Rating and Assessing Industrial and Commercial Sound*.

Predictions have been carried out based on an example ABB transformer with a sound pressure level of ≤50 dB(A) at 2 m. Using the dimensions of the transformer, the sound power level was calculated to be 76 dB(A). The octave band profile for the transformer has been sourced from 'An Introduction to Sound Level Data for Mechanical and Electrical Equipment' published by CED Engineering. The A-weighted octave band data is presented in Table 7.21.

Table 7.21: Octave Band Sound Power Level Data

Equipment	A-weighted Octave Band Centre Frequency (Hz)									Overall
	31.5	63	125	250	500	1k	2k	4k	8k	L_{WA}
Transformer Ω	64	70	72	67	67	61	56	51	44	**76**
Ω - Manufacturer's datasheet provided information on overall sound power levels. Octave band data was sourced from 'An Introduction to Sound Level Data for Mechanical and Electrical Equipment' CED Engineering										

Noise predictions have also been carried out using International Standard ISO 9613, *Acoustics – Attenuation of Sound during Propagation Outdoors*. A worst case with plant producing their highest noise emissions has been assumed. The parameters assumed are identical to those for on-site operations. Predicted results are presented in Table 7.22. The results of the operational transformer noise predictions show that predicted rating noise levels (includes a 6 dB penalty for potential tonal noise from transformer) at the nearest residential dwelling is 24.6 dB $L_{Ar,Tr}$. It should be noted that rating levels below 35 dB $L_{Ar,Tr}$ are considered to be very low (see Section 7.3.3.3) and is not considered to be significant. However, there is also an existing substation at Kellistown and permission has been granted for battery storage. The cumulative impact for all developments is outlined in Section 7.5.5.3.

Table 7.22: Predicted Rated Noise from Off-Site Transformer at Kellistown

Receptor ID	Predicted Noise Levels ($L_{Ar,Tr}$)			Receptor ID	Predicted Noise Levels ($L_{Ar,Tr}$)	
	Ground Floor	First Floor			Ground Floor	First Floor
K1	24.6	24		K12	20.3	20.1
K2	22.2	21.7		K13	20.4	20.1
K3	21.6	21.2		K14	19.3	19.1
K4	22.2	21.8		K15	16.3	16.3
K5	19.9	17.6		K16	15.8	15.7
K6	19.9	17.6		K17	16.3	16.3

Receptor ID	Predicted Noise Levels ($L_{Ar,Tr}$)			Receptor ID	Predicted Noise Levels ($L_{Ar,Tr}$)	
	Ground Floor	First Floor			Ground Floor	First Floor
K7	16.7	16.6		K18	17.7	17.6
K8	18.9	18.7		K19	17.9	17.7
K9	19.4	19.2		K20	17.4	17.3
K10	21.7	21.3		K21	16.7	16.6
K11	21.4	21		K22	16.7	16.6

7.5.4 Potential Impacts during Decommissioning

On decommissioning, cranes will disassemble the above ground turbine components which would be removed off site for recycling. All the major component parts are bolted together, so this is a relatively straightforward process. The foundations will be covered over and allowed to re-vegetate naturally. It is proposed that the internal site access tracks will be left in place.

Grid connection infrastructure including substations and ancillary electrical equipment shall form part of the national grid and will be left in situ.

The recreational trails and associated signage shall be left in situ.

These activities will be undertaken during daytime hours, and noise, which will be of a lesser impact than for construction, will be controlled through the relevant guidance and standards in place at the time of decommissioning.

A detailed decommissioning plan will be agreed in advance of construction with Carlow County Council. A decommissioning plan is contained in the CEMP in Appendix 3-1 of Volume 3.

7.5.5 Potential Cumulative Impacts

7.5.5.1 Construction Phase

In terms of cumulative impacts with other projects, it is not expected that there will be cumulative impacts with other large or small scale developments in the vicinity of the proposed wind farm. However, there is potential cumulative impacts with commercial forestry harvesting. The Commercial forestry harvesting may be an intermittent increase in noise levels in the vicinity of the proposed wind farm site during the construction phase, as a result of the use of machinery for timber harvesting works. These impacts will be short-term in duration. Noise at any given noise sensitive location will be variable throughout the harvesting works, depending on the distance from the machinery to the receiving dwellings.

There is a potential cumulative impact from the proposed off-site substation (which forms part of the project) and the consented Kellistown Battery Storage Facility. A predicted noise level of approximately 53 dB L_{Aeq} was reported in the Kellistown Battery Storage Facility noise impact assessment at the nearest receptor approximately 200m away. The predicted in combination noise level is 58.1 dB $L_{Aeq,1hr}$which is below the noise limit of 65 dB $L_{Aeq,1hr}$.

7.5.5.2 Operational Phase

There are several wind farms within 20 km of the site including Ballaman, Ballindaggin, Ballon, Ballycadden, Ballynancoran, Carranroe, Castledockrell, Cronelea, Gibbet Hill, Greenoge, Knockalour, Monaughrim, Shillelagh and Tullow Mushroom Growers. Greenoge Wind Farm in the immediate vicinity of the proposed project, and is located directly east of the proposed wind farm site. Using the IOA GPG, it is not necessary to consider cumulative noise from all these wind farms, as these are considered sufficiently distant as the predicted noise from these wind farms is at least 10 dB less than the predicted levels of the proposed Croaghaun Wind Farm. Greenoge Wind Farm is the only wind farm that meets the IOA GPG criteria. Greenoge Wind Farm consists of 5 no. of turbines including 4 no. of Nordex N60/1300 and 1 no. of Nordex N90/2500. The sound power data for the Nordex N60/1300 and Nordex N90/2500 turbines are presented in Appendix 7.5.

Table 7.23 presents predicted noise levels adjacent to the 10 noise monitoring locations. The locations presented represent the dwellings with the highest noise levels for each of the 10 monitoring locations. The predicted noise levels at all receptor locations are presented in Appendix 7.7. Note: the predicted noise levels are for a worst-case scenario with noise sensitive receptors downwind of the proposed wind farm.
In practice, receptor locations will not be downwind of all noise sources and the actual noise levels will be lower than those presented in Table 7.23 and Appendix 7.7.

The cumulative predicted noise levels comply with the daytime and night-time limits at the majority of noise sensitive locations. The only exceedance is during night-time periods at location R39 at standardised 10m height wind speeds of 11 and 12 m/s. The dominant noise at this receptor is from Greenoge Wind Farm. At a standardised 10 m height wind speeds of 11 and 12 m/s the noise from Greenoge Wind Farm is 42.1 and 43.4 dB, respectively. Mitigation measures are outlined in Section 7.6.2.

Table 7.23: Assessment of Cumulative Predicted L_{A90} Noise Levels for Croaghaun Wind Farm and Greenoge Wind Farm against Noise Limits

Receptor ID	Description	Predicted L_{A90} Sound Pressure Level at 10m Standardised Wind Speed, dB									
		3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
H1	Predicted Level	25.3	28.6	32.6	36.3	37.1	37.4	37.5	37.6	37.8	38.0
	Daytime limit	37.5	37.5	37.5	37.5	37.5	37.5	45.0	45.0	45.0	45.0
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H3	Predicted Level	28.7	31.5	35.2	38.7	39.6	39.9	40.1	40.3	40.6	40.9
	Daytime limit	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.4
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H19	Predicted Level	28.7	30.8	34.2	37.4	38.3	38.7	39.0	39.3	39.8	40.3
	Daytime limit	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.0	47.1	51.7
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H21	Predicted Level	21.7	25.5	29.8	33.6	34.4	34.7	34.7	34.8	34.9	35.0
	Daytime limit	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.3
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H39	Predicted Level	33.7	34.9	37.3	39.9	40.9	41.5	42.0	42.7	43.5	44.5

Receptor ID	Description	Predicted L_{A90} Sound Pressure Level at 10m Standardised Wind Speed, dB									
		3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
	Daytime limit	37.5	45.0	45.0	45.0	45.0	45.0	45.0	46.0	47.5	47.5
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	**0.5**	**1.5**
H46	Predicted Level	21.3	25.0	29.2	33.0	33.9	34.1	34.2	34.2	34.3	34.5
	Daytime limit	37.5	37.5	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.6
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H47	Predicted Level	21.0	24.6	28.8	32.5	33.4	33.7	33.8	33.8	33.9	34.1
	Daytime limit	45.0	45.0	45.0	45.0	45.0	45.0	45.0	46.1	48.6	51.5
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H52	Predicted Level	29.8	31.2	33.9	36.7	37.7	38.2	38.7	39.3	40.0	40.8
	Daytime limit	37.5	37.5	45.0	45.0	45.0	45.0	45.0	45.0	45.7	46.6
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H120	Predicted Level	31.2	33.0	35.9	39.0	39.9	40.4	40.7	41.2	41.8	42.5
	Daytime limit	37.5	37.5	45.0	45.0	45.0	45.0	45.0	47.1	49.6	49.6
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0

Receptor ID	Description	Predicted L_{A90} Sound Pressure Level at 10m Standardised Wind Speed, dB									
		3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s
	Night-time Excess	-	-	-	-	-	-	-	-	-	-
H175	Predicted Level	21.9	25.6	29.9	33.6	34.6	34.8	34.9	34.9	35.0	35.1
	Daytime limit	37.5	37.5	37.5	37.5	45.0	45.0	45.0	45.0	45.0	47.8
	Daytime Excess	-	-	-	-	-	-	-	-	-	-
	Night-time limit	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0
	Night-time Excess	-	-	-	-	-	-	-	-	-	-

In addition to the adjacent wind farm, there is potential for commercial forestry harvesting to occur during the operational phase of the wind farm. The noise emissions from the commercial forestry harvesting and the operational wind farm are very different and there is no one single standard on which both activities can be assessed. The commercial forestry harvesting may be an intermittent increase in noise levels in the vicinity of the proposed wind farm site during the operational phase, as a result of the use of machinery for timber harvesting works. These impacts will be short-term in duration. Noise at any given noise sensitive location will be variable throughout the harvesting works, depending on the distance from the machinery to the receiving dwellings.

7.5.5.3 Operational Phase – Off-site Substation

It was demonstrated in Section 7.5.3.2 that the predicted noise from the proposed off-site substation at Kellistown has a rating level below about 35 dB LAr,Tr which is considered to be very low (see Section 7.3.3.3) and is not considered to be significant. However, there is also an existing substation at Kellistown with two transformers and permission has been granted for battery storage. The cumulative impact for all developments is assessed in this section.

The predicted noise levels from the consented Kellistown East Energy Storage Facility with mitigation has a maximum predicted noise level of 35 dB L_{Aeq}. Note: the battery storage facility noise assessment did not include receptors K13 – K22.

No details were found on the existing substation at Kellistown. However, measurements for a similar substation at Gormanstown 110/220 kV substation are presented in *EirGrid Evidence Based Environmental Studies Study 8: Noise, Literature review and evidence based field study on the noise effects of high voltage transmission development* (May 2016). Measurement undertaken 10 m from the southern and western boundary were used to estimate the source power of the transformers on site.

The noise emissions from the consented battery storage and existing substation are the dominant sources and in combination with the proposed off-site substation will result in a negligible impact. The predicted cumulative noise from all developments are presented in Table 7.24 with highest predicted level of 35.6 dB at K5 which is closest to consented battery storage facility.

Table 7.24: Predicted Rated Noise from Off-Site Transformer at Kellistown

Receptor ID	Predicted Noise Levels ($L_{Ar,Tr}$)			Receptor ID	Predicted Noise Levels ($L_{Ar,Tr}$)	
	Ground Floor	First Floor			Ground Floor	First Floor
K1	32.6	32.7		K12	28.9	29.0
K2	31.1	31.2		K13	26.2	26.7
K3	29.5	29.8		K14	25.9	26.5
K4	31.1	31.4		K15	24.6	25.3
K5	35.5	35.6		K16	23.8	24.5
K6	33.7	33.8		K17	23.5	24.2
K7	28.2	28.3		K18	24.2	24.8
K8	28.7	28.9		K19	24.2	24.9
K9	28.2	28.5		K20	23.7	24.4
K10	33.8	33.9		K21	23.0	23.7
K11	33.8	33.9		K22	23.2	23.9

7.6 Mitigation Measures

7.6.1 Mitigation Measures During Construction

The predicted noise levels from on-site activity from the proposed project is below the noise limits in BS 5228-1:2009+A1:2014. Nonetheless, several mitigation measures will be employed to minimise any potential impacts from the proposed project.

The noise impact for construction works traffic will be mitigated by generally restricting movements along access routes to the standard working hours and exclude Sundays, unless specifically agreed otherwise. For example, during turbine erection, an extension to the working day may be required, i.e. 05:00 to 21:00, but this would be necessary only on a relatively small number of occasions. If turbine deliveries are required at night it will be ensured that vehicles on local roads do not wait outside residential properties with their engines idling, and that the local residents will be informed of any activities likely to occur outside of normal working hours.

Consultation with the local community is important in minimising the impacts and therefore construction will be undertaken in consultation with the local authority as well as the residents being informed of construction activities through the Community Liaison Officer.

The construction works on site will be carried out in accordance with the guidance set out in BS 5228:2009+A1:2014, and the noise control measures set out Section 4.3.2 of the Construction Environmental Management Plan (CEMP). Proper maintenance of plant will be employed to minimise the noise produced by any site operations.

All vehicles and mechanical plant will be fitted with effective exhaust silencers and maintained in good working order for the duration of the project. Machinery that is used intermittently will be shut down or throttled back to a minimum during periods when not in use.

The hours of construction activity will be limited to avoid unsociable hours where possible. Construction operations shall generally be restricted to between 07:00 - 19:00 hours Monday to Friday and 07:00 - 13:00 hours on Saturdays. However, to ensure that optimal use is made of fair-weather windows, or at critical periods within the programme, it could occasionally be necessary to work outside these hours. Any such out of hours working would be agreed in advance with the local planning authority.

The on-site construction and decommissioning noise levels will be below the relevant noise limit of 65 dB $L_{Aeq,1hr}$ for operations exceeding one month, and therefore construction noise impacts are not considered to be significant. However, there is potential for temporary elevated noise levels due to the grid connection works. However, the impact of these works at any particular receptor will be for a short duration (i.e. typically less than 3 days). Where the works at elevated noise levels are required over an extended period at a given location, a temporary barrier or screen will be used to reduce noise levels below the noise limit where required. The noise impact will also be minimised by limiting the number of plant items operating simultaneously where reasonable practicable.

7.6.2 Mitigation Measures during Wind Farm Operation

The predicted cumulative noise from the proposed project and Greenoge Wind Farm is above the night-time noise limit at receptor R39 at wind speeds of 11 and 12 m/s. The dominant noise at this receptor is from Greenoge Wind Farm.

At a standardised 10m height wind speeds of 11 and 12 m/s the noise from Greenoge Wind Farm is 42.1 and 43.4 dB, respectively. In order to demonstrate compliance with the with the night-time noise limit, mitigation is required.

However, at 12 m/s the predicted noise level from Greenoge Wind Farm only is above the noise limit. Therefore, it is not possible to demonstrate compliance at this wind speed. Instead, it is proposed that the noise emissions from Croaghaun Wind Farm will be maintained at 10 dB below the predicted operational noise from Greenoge and on that basis, the contribution to the cumulative noise at this location will result in a negligible increase in cumulative noise. This follows guidance in the HMP Report and the IOA GPG[8].

In order to ensure the proposed wind farm is compliant with the noise limits, some of the turbines may need to be operated in noise reduced modes of operation[9]. Table 7.25 presents the sound power levels for the Siemens Gamesa SG 5.0-132 with TES for noise reduced modes of operation and a range of standardised 10m height wind speeds.

Table 7.25: Siemens Gamesa SG 5.0-132 with TES – Octave Band Sound Power Levels for a range of Noise Reduced Modes of Operation at Wind Speeds of 11 and 12 m/s

Modes of Operation	Centre Frequency (Hz)									LwA
	31.5	63	125	250	500	1000	2000	4000	8000	
Normal Operation	77.4	88.2	95.0	98.6	99.7	100.8	98.5	92.2	83.0	106.2
NRS Mode N1	75.6	86.2	92.6	95.8	96.9	98.0	95.7	89.4	80.2	103.4
NRS Mode N2	75.6	86.0	92.3	95.4	96.5	97.6	95.3	89.0	79.8	103.0
NRS Mode N3	75.3	85.4	91.1	93.7	94.8	95.9	93.6	87.3	78.1	101.4
NRS Mode N4	75.1	85.0	90.4	92.7	93.8	94.9	92.6	86.3	77.1	100.4
NRS Mode N5	74.9	84.5	89.6	91.6	92.7	93.8	91.5	85.2	76.0	99.4
NRS Mode N6	74.6	83.8	88.3	89.8	90.9	92.0	89.7	83.4	74.2	97.7
NRS Mode N7	74.4	83.3	87.5	88.8	89.8	91.0	88.7	82.4	73.2	96.7
NRS Mode N8	74.3	83.0	86.8	87.8	88.9	90.0	87.7	81.4	72.2	95.8

[8] The HMP Report (See References) states that "*If an existing wind farm has permission to generate noise levels up to ETSU-R-97 limits, planning permission noise limits set at any future neighbouring wind farm would have to be at least 10 dB lower than the limits set for the existing wind farm to ensure there is no potential for cumulative noise impacts to breach ETSU-R-97 limits.*" The IOA GPG states…. in cases "*where noise from the proposed wind farm is predicted to be 10 dB greater than that from the existing wind farm (but compliant with ETSU-R-97 in its own right), then a cumulative noise impact assessment would not be necessary*." The same principle is argued for Croaghaun Wind Farm in that the noise emissions from Croaghaun Wind Farm will be 10 dB below those from Greenoge Wind Farm and will have a negligible impact.

[9] It is possible to run the turbines in noise reduced modes of operation (NROs) whereby the noise level is lessened by reducing the rotational speed of the turbines, with a resultant loss of electrical energy production. NRS Mode N1 refers to a noise reduced mode with a sound power of 103.4 dB rather than 106.2 dB when the turbine operates in normal mode of operation.

A range of mitigation strategies can be developed to ensure compliance with the noise limits. Table 7.26 presents mitigation measures to ensure compliance with the night-time noise limit. It should be noted that the proposed curtailment strategies are not exhaustive; there may be several other configurations/alternatives that would allow noise limits to be met and that an appropriate mitigation strategy may be specified for the procured turbine model prior to construction of the wind farm. The operational noise resulting from the proposed project will meet the noise limits set out in Section 7.4.2 or be at least 10 dB below the noise level from Greenoge Wind Farm.

The predicted noise levels with mitigation measures are presented in Appendix 7.8. With mitigation, for some receptors sufficiently far from Greenoge Wind Farm a new source of noise will be introduced into the soundscape and it is expected that there will be a long-term slight to moderate significance of impact for dwellings within the 35 dB L_{A90} study area with a moderate significance of impact on the closest dwellings to the proposed wind farm.

Table 7.26: Required Turbine Curtailment/Mitigation to Meet Daytime Noise Limits

Turbine ID	Required Noise Reduced Modes to meet Night-time Noise Limit L_{A90}	
	Standardised 10m Height Wind Speeds (m/s)	
	11	12
T1	NO	NRO
T2	NO	NRO
T3	NO	NRO
T4	NO	NRO2
T5	NO	NRO1
T6	NRO2	NRO5
T7	NRO4	NRO8

As discussed previously, the operational noise predictions have been carried out for the Siemens Gamesa SG5.0 132 which is the worst performing turbine from a noise perspective of several turbines assessed that meet the dimensional envelope of the proposed project. Therefore, the proposed mitigation measures only apply to the turbine considered in this assessment. It may be the case that mitigation will not be required for the turbine that is selected for the site.

is the worst performing from a noise perspective of several turbines assessed that meet the dimensional envelope of the proposed project. The actual turbines to be installed at the proposed wind farm will be the subject of a competitive tender process and may include turbines not amongst the turbine models currently available. Regardless of the make or model of the turbine eventually selected for installation on site, the noise it will give rise to will be of no greater significance than that used for the purposes of this assessment to ensure that the findings remain valid.

As stated above it should be noted that the proposed curtailment strategies are not exhaustive; there may be several other configurations/alternatives that would allow noise limits to be met and that an appropriate mitigation strategy may be specified for the procured turbine model prior to construction of the wind farm.

The finalised mitigation measures to be implemented at the site will be chosen to ensure that the noise limits are met.

The noise modelling undertaken assesses a worst-case scenario with all noise sensitive locations downwind of all wind turbines. In practice, it is expected that the actual noise levels from the proposed project will be less than those predicted and hence, the extent of the mitigation will also be reduced. Ultimately, the derived noise limits in Section 7.4.2 will guide the turbine selection and operation, and noise limits will be complied with.

Should the project be granted permission, an operational noise survey will be undertaken to ensure the project complies with the noise limits. If an exceedance in the noise limit occurs, mitigation measures will be refined to ensure compliance with the noise limits is achieved at all noise sensitive locations.

7.6.3 Mitigation Measures during Decommissioning

The noise impact for construction works traffic will be mitigated by generally restricting movements along access routes to the standard working hours and exclude working on Sundays, unless specifically agreed otherwise with the local authority.

The decommissioning works, which will be of a lower impact than construction works, will be carried out in accordance with the policies and guidance required at the time of the works, and restricted to normal working hours, typically 07:00 - 19:00 hours Monday to Friday and 07:00 - 13:00 on Saturdays.

7.7 Residual Impacts

Construction and decommissioning on-site activities with a duration longer than one month will be below the construction noise limit of 65 dB $L_{Aeq,1hr}$ at residential dwellings. As a result, residual construction impacts range between not significant to slight impact with the duration of impact described as temporary.

There is potential for elevated noise levels due to the grid connection works resulting in a temporary significant impact. However, these works will be for a short duration at a particular property (i.e. typically less than 3 days at any particular receptor) and where the works are to occur over an extended period at a given location, a temporary barrier or screen will be used to reduce noise level below the noise limit and reduce any potential impact resulting in a moderate short-term residual impact.

The operational wind farm noise levels meet the daytime noise limit derived using the Wind Energy Development Guidelines 2006. With mitigation measures, operational wind farm noise levels meet the night-time noise limit derived using the Wind Energy Development Guidelines 2006 which is not considered to be a significant impact. However, for some receptors a new source of noise will be introduced into the soundscape and it is expected that there will be a slight to moderate significance of impact, with dwellings closest to the project with a long-term moderate significance of impact.

7.8 References

Irish Wind Energy Association, Best Practice Guidelines for the Irish Wind Energy Industry, 2012

Department of the Environment, Heritage, and Local Government, Wind Energy Development Guidelines, 2006

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Ireland
+353 21 496 4133

Dublin Office
J5 Plaza,
North Park Business Park,
North Road, Dublin 11, D11 PXT0,
Ireland
+353 1 658 3500

Carlow Office
Unit 6, Bagenalstown Industrial Park, Royal Oak Road,
Muine Bheag,
Co. Carlow, R21 XA00,
Ireland
+353 59 972 3800