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CLEANRATH WIND FARM COMPLIANCE NOISE MONITORING AND ASSESSMENT

Technical Report Prepared For

Cleanrath Windfarm Ltd

Technical Report Prepared By

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EXECUTIVE SUMMARY

AWN Consulting Limited (AWN) has been commissioned by Cleanrath Windfarm Ltd to assess the operational turbine noise emissions at a number of residences in the vicinity of the Cleanrath wind turbine development in Co. Cork. This assessment has been conducted with consideration of the planning condition noise criteria applicable to the development and noise monitoring conducted in March to May 2020.

Condition 7 of the grant of planning relates to noise and states:

> "*Wind turbine noise arising from the proposed development, by itself or in combination with other existing or permitted wind energy development in the vicinity, shall not exceed the greater of*
>
> *(a) 5 dB(A) above background noise levels, or*
> *(b) 43 dB(A)*
>
> *When measured externally at dwellings or other sensitive receptors.*
>
> *Prior to the commencement of the development, the developer shall submit to, and agree in writing with, the planning authority a noise compliance monitoring programme for the subject development. All noise measurements shall be carried out in accordance with ISO Recommendation 1996 "Acoustics – Description, measurement and assessment of environmental noise". The results of the initial noise compliance monitoring shall be submitted to, and agreed in writing with, the planning authority within six months of commissioning of the wind farm."*

The assessment of the measured noise levels over a range of wind speeds from 3 to 8m/s is presented in Table A:

Loc.	Ref	dB L_{A90} at 10m standardised wind speed (m/s)					
		3	4	5	6	7	8
C04	Measured Cumulative Noise Level	26.1	28.4	31.3	34.1	36.6	38.1
	Noise Criterion	43	43	43	43	43	43
	Complies?	✓	✓	✓	✓	✓	✓
C18	Measured Cumulative Noise Level	24.1	25.5	27.8	30.4	32.8	34.4
	Noise Criterion	43	43	43	43	43	43
	Complies?	✓	✓	✓	✓	✓	✓
C23	Measured Cumulative Noise Level	22.3	26.2	29.4	31.8	33.6	34.5
	Noise Criterion	43	43	43	43	43	43
	Complies?	✓	✓	✓	✓	✓	✓

Table A Assessment of Turbine Noise Levels ($L_{A90,10min}$) for Various Wind Speeds

The noise levels in Table A are representative of downwind i.e. worst-case conditions and are cumulative levels (i.e. turbine noise and background noise from other sources). The values are within the relevant noise criteria at all wind speeds. It can therefore be concluded that the Cleanrath wind farm is operating in compliance with the relevant planning condition.

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1.0 INTRODUCTION

This document describes the assessment undertaken to review the operational noise emissions form the constructed wind farm development at Cleanrath, Co. Cork.

The Cleanrath Wind Farm development was granted planning permission subject to compliance with a number of Conditions. Condition 7 of the planning permission sets out noise limits for the development, the applicable noise criteria are discussed in detail Section 2.0.

The constructed development consists of nine Nordex N117 turbines with a hub height (HH) of 91m. Figure 1 illustrates the positioning of the turbines and noise monitoring locations.

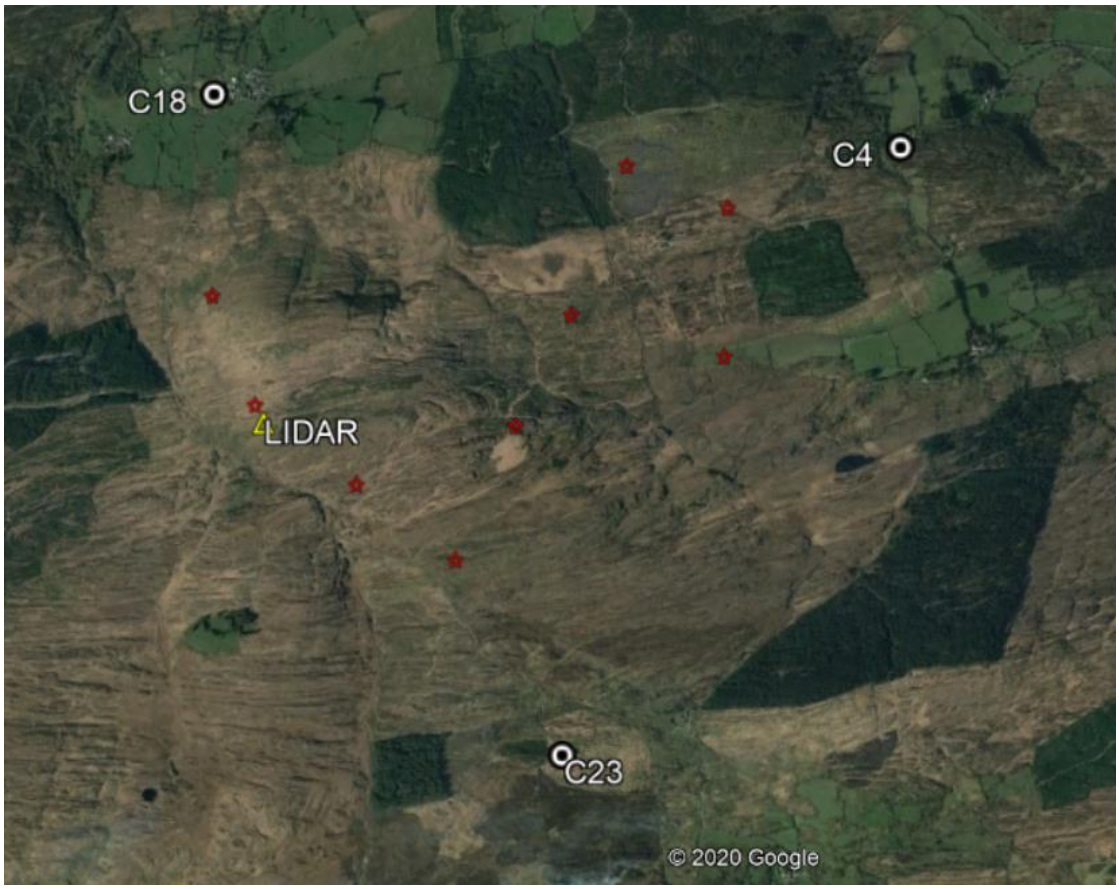


Figure 1 Turbine Positions and noise monitoring locations

A comprehensive noise commissioning survey has been carried out at 3 no. properties surrounding the Cleanrath Wind Farm site. In order to assess compliance with Condition 7 of the Grant of Planning (An Bord Pleanála Ref. 04.246742) the following steps present a summary of the assessment methodology:

- Review and comment on the relevant planning condition that relates to the windfarm site operations.
- Processing, through regression analysis, of the measured noise levels to derive specific turbine noise levels that are experienced at various wind speeds.
- Review of these noise levels in light of the content of the relevant planning condition.

Appendix A of this document presents a glossary of acoustic terminology used throughout this report.

2.0 RELEVANT PLANNING CONDITION REVIEW

The relevant planning condition relating to noise emissions from the Cleanrath site is discussed below.

Condition 7 of the Grant of Planning issued by An Bord Pleanála (ABP) Ref. PL 04.246742 is relevant to this assessment and states:

> "*Wind turbine noise arising from the proposed development, by itself or in combination with other existing or permitted wind energy development in the vicinity, shall not exceed the greater of*
>
> *(a) 5 dB(A) above background noise levels, or*
> *(b) 43 dB(A)*
>
> *When measured externally at dwellings or other sensitive receptors.*
>
> *Prior to the commencement of the development, the developer shall submit to, and agree in writing with, the planning authority a noise compliance monitoring programme for the subject development. All noise measurements shall be carried out in accordance with ISO Recommendation 1996 "Acoustics – Description, measurement and assessment of environmental noise". The results of the initial noise compliance monitoring shall be submitted to, and agreed in writing with, the planning authority within six months of commissioning of the wind farm."*

In the first instance it should be noted that the noise limits stated above relate to wind turbine noise in isolation. The following comments are made in relation to this planning permission Condition:

As the Irish Wind Energy Development Guidelines[1] (WEDG) on wind turbine noise are broadly based on ETSU-R-97 it is therefore proposed to carry out this aspect of the review considering the guidance within *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Noise from Wind Turbines. The Institute of Acoustics (IoA), May 2013* and supplementary guidance notes (IoA GPG). The IoA states the following in relation to the scope and purpose of the document:

1.2.1 This guide presents current good practice in the application of the ETSU-R-97 assessment methodology for all wind turbine developments above 50 kW, reflecting the original principles within ETSU-R-97, and the results of research carried out and experience gained since ETSU-R-97 was published.

1.3.1 This Good Practice Guide has been approved by the IoA Council for use by IoA Members and others involved in the assessment and rating of wind turbine noise using ETSU-R-97. It covers technical matters of an acoustic nature which the IoA-NWG believes represent current good practice.

It is noted here that guidance for licenced EPA sites (while not directly applicable here) as outlined in the Environmental Protection Agency *"Guidance Note on Noise Assessment of Wind Turbine Noise at EPA Licensed Sites (NG3)"* is comparable to that outlined in *A Good Practice Guide to the Application of ETSU/R/97 for the Assessment and Rating of Noise from Wind Turbines.* It is therefore considered that

[1] Wind Energy Development Guidelines, Section 5.6. Department of the Environment, Heritage and Local Government, 2006.

the IoA approach is a robust assessment methodology and represents best practice typically adopted in Ireland and the United Kingdom.

The planning condition does not specify the acoustic parameter to which the decibel quantities refer; in keeping with the WEDG, ETSU-R-97 and IoA GPG, this is understood to refer to the L_{A90} parameter.

AWN have conducted a series of commissioning noise measurements at three locations in the vicinity of the Cleanrath site. This data has been used in order compare the actual turbine noise levels to the limit values outlined above.

The assessment can be somewhat simplified by considering the 'rated power' of the turbines in question. Modern wind turbines begin generating electricity at low wind speeds referred to as 'cut-in' wind speed. Maximum power output is typically reached at wind speeds of around 10 m/s at hub height[2], referred to as 'rated power'. At greater wind speeds the rotational speed of the turbine blades must be controlled to prevent damage, this results in a situation that noise emissions associated with a turbine do not increase above rated power wind speed.

Section 2.9 of the IoA GPG recommends that for pitch-regulated turbines the data captured should cover the range of wind speeds between cut-in and the speed at which maximum sound power level is achieved. Here, for clarity noise levels are presented and assessed for wind speeds between 3m/s and 8 m/s at standardised 10 m height.

Turbine coordinates and models are presented in Table 1. Overall A-Weighted sound power levels (L_{wA}) have been supplied for the Nordex N117 turbines that are installed on the site (3.6 MW and 2.4 MW versions). These levels are presented in Tables 2 and Table 3.

ID	Irish Grid Coordinates		Turbine Model	Hub Height (m)
	Easting	Northing		
C-T06	119,466	69,620	N117 3.6MW	91
C-T07	119,610	69,250	N117 3.6MW	91
C-T09	119,952	68,981	N117 3.6MW	91
C-T10	120,288	68,725	N117 3.6MW	91
C-T08	120,493	69,178	N117 2.4MW	91
C-T05	120,682	69,553	N117 2.4MW	91
C-T04	121,200	69,411	N117 2.4MW	91
C-T03	121,213	69,913	N117 2.4MW	91
C-T01	120,871	70,057	N117 2.4MW	91

Table 1 Details of Turbines at Cleanrath Wind Farm

Standardised 10m Height Wind Speed (m/s)	Overall Sound Power Level, dB(A)
3	92.5
4	94.5
5	100.0
6	103.0
7	103.5
8	103.5
9	103.5

Table 2 Cleanrath Turbine Noise Emissions for Nordex N117/3.6MW, HH of 91m – Serrated trailing edge version. Source: Nordex document ref F008_256_A14_EN dated 24 January 2020

[2] This 10m/s hub height wind speed typically equates to 7m/s standardised 10m height which noise monitoring results are reported to as a matter of best practice.

Standardised 10m Height Wind Speed (m/s)	Overall Sound Power Level, dB(A)
3	94.0
4	97.0
5	101.0
6	101.5
7	102.0
8	102.0
9	102.0

Table 3 Cleanrath Turbine Noise Emissions for Nordex N117/2.4MW, HH of 91m – Serrated trailing edge version. Source: Nordex document ref F008_146_A14_EN dated 12 October 2018

Review of the data contained in Tables 2 and 3 confirms that the noise emissions from the installed turbines reach a maximum level at 7 m/s wind speed (standardised 10m height), this is referred to as the rated power wind speed. At wind speeds above rated power wind speed, the rotation of the turbine blades is maintained. As a result, noise emissions associated with a turbine operation do not increase at wind speeds above the rated power wind speed. Best practice in terms of the assessment of wind turbine noise accepts that, if it can be demonstrated that the relevant criteria can be complied with up to the rated power wind speed (7 m/s), then it can be judged to be satisfied at higher wind speeds. Although the wind turbines at Derragh have a rated wind speed of 9m/s speed (standardised 10m height), this does not have a material influence on the downwind noise levels at 7m/s any of the survey locations. Any increases in the overall measured noise level above rated power wind speed will typically be related to an increase in wind generated noise in surrounding trees and foliage which are not associated with turbine operation; this approach has been adopted for this assessment.

The LIDAR installation report is included here as Appendix C.

3.0 SITE NOISE MONITORING

This stage of the assessment was to determine typical noise levels at a number of noise sensitive locations in the vicinity of the development. This was done through installing unattended sound level meters at three representative locations for a sufficient length of time to ensure collation of data across wind speeds of interest in line with best practice. The noise surveys have been carried out in accordance with guidance contained in the IoA GPG.

3.1 Choice of Measurement Locations

The measurement locations were spread around the site and all of the locations are situated at residential dwellings typically surrounded by rural farmland.

As part of the planning compliance process three noise monitoring locations were selected, as outlined in Table 4. These are the locations referred to in the Condition Compliance Submission[3], and they are considered representative of the nearest noise-sensitive locations around the wind farm.

Location (House ID)	Co-ordinates (IG)	
	Easting	Northing
C04	121,810	70,134
C18	119,495	70,299
C23	120,666	68,076

Table 4 Co-Ordinates of Noise Monitoring Equipment

Figures 2 to 4 illustrate the various meter installations that were placed at the monitoring locations over the course of the survey programme.

Figure 2 Monitoring Installation at C04

[3] Cleanrath Wind Farm Condition Compliance Statement Ref 110721e- Cleanrath Wind Farm- CCS-2018.06.06 F1

Figure 3 Monitoring Installation at C18 – yellow oval shows location of microphone. In this instance, spaces closer to the house were contained livestock and as such were not suitable for an unattended meter

Figure 4 Monitoring Installation at C23

3.2 Measurement Periods

Noise measurements were conducted at each location between the following periods:

Location	Start Time and Date	End Time and Date
C04	26 March 2020	27 April 2020
C18	26 March 2020	7 May 2020
C23	26 March 2020	7 May 2020

Table 5 Noise Monitoring Periods

The monitoring periods were of sufficient duration to ensure that adequate data sets were measured at the necessary wind speeds and direction for all locations.

3.3 Instrumentation

AWN Consulting installed and maintained all of the noise monitors. The following instrumentation was used at the various locations:

Location	Equipment	Serial Number	Maximum Calibration Drift
C04	Rion NL-52	575782	0.0
C18	Rion NL-52	564809	0.0
C23	Rion NL-52	564808	+0.1

Table 6 Noise Monitoring Equipment Details

Before, during and after the survey the measurement apparatus was check calibrated using a Brüel & Kjær type 4231 Sound Level Calibrator where appropriate. Details of instrumentation calibration are presented in Appendix B. The maximum drift was within the tolerances outlined in the IoA GPG.

3.4 Procedure

Measurements were conducted at the residences on a continuous basis during the periods identified in Section 3.2. Sample periods for the noise measurements were 10 minutes during all periods. The results were saved to the instrument memory for later analysis. Survey personnel noted potential primary noise sources contributing to noise build-up during the installation and removal of the sound level meters from site (e.g. identified significant noise sources in the area such as local traffic or farm yard activities). L_{Aeq} and L_{A90} parameters were measured.

4.0 ASSESSMENT METHODOLOGY

The following sections present an overview of the statistical analysis on the noise monitoring data collated during the survey. Consideration has been given to the relevant assessment criteria discussed in Section 2.0 and measurement methodology outlined in Section 3.0.

4.1 Assessment Periods

For compliance assessments, the IoA GPG Supplementary Guidance Note No 5 Post Completion Measurements proposes a method of filtering out all data except that measured between 23:00 and 04:00hrs when competing noise would be at a minimum. This has been applied to the noise data sets in all cases.

4.2 Downwind Assessment

It is standard practice to consider downwind noise conditions due to the propagation effects of wind turbines. Typically, in crosswind conditions turbine noise propagation can be attenuated up to 2 dB and in upwind conditions this attenuation can be up to 10 dB, depending on the distance to the turbine. In accordance with the IoA GPG a wind directionality review (i.e. worst case – downwind of the nearest turbines) has been carried out to determine the operational noise levels.

Section 2.1.7 of the IoA GPG SGN 5 states:

> *"For very large or extended wind farms, it may not always be relevant to consider downwind directions from all wind turbines, and instead consider the turbines primarily contributing to receptor noise levels (or 'primary turbines'). It is suggested that these are determined such that the predicted difference between noise immission levels with all turbines operating and the primary turbines operating be less than 0.5 dB and that this is determined separately for each survey location."*

The above guidance has been adopted in determining the appropriate downwind directions that should be considered at each location.

4.3 Atypical Noise Data

The data sets have been filtered to remove outliers such as the dawn chorus and the influence of other atypical noise. An example of atypical noise would be short isolated periods of raised noise levels attributable to local sources, agricultural activity, boiler flues, operation of gardening equipment etc. This approach is in line with the guidance contained in the IoA GPG.

4.4 Operational Noise Levels

The measured wind speed data has been plotted against the measured noise data and a best-fit polynomial trendline has been selected for each data set in accordance with the guidance contained in the IoA GPG in order to derive the total measured operational noise level at each of the relevant wind speed bins.

The measured operational noise levels are considered worst case as they comprise all noise in the area (i.e. background noise and noise from the operation of the turbines).

With respect to the guidance contained in the IoA GPG, the collated datasets are adequate for the purposes of assessing the operational turbine noise against the relevant assessment criteria.

4.5 Turbine Noise Levels

The method outlined in the IoA GPG to determine turbine specific noise levels is to review data during night-time hours when competing noise (i.e. noise from 'other' non-turbine source) is typically at a minimum. As the turbines operate in the same mode of operation for both day and night-time periods, review of the night time data sets provides a more accurate indication of the specific turbine noise as a means to assessing compliance. In instances where limited directional data has been captured between 23:00 and 04:00hrs, data from outside of these hours has be included in the assessment.

Modern wind turbines begin generating electricity at wind speeds typically around 3m/s, referred to as 'cut-in' wind speed. Maximum power output is reached at 'rated power' wind speed. At wind speeds above rated power, the rotational speed of the turbine blades must be controlled to prevent damage. The result of this is that noise emissions associated with a turbine operation do not increase above 'rated power' wind speed.

Overall A-weighted sound power levels (L_{WA}) have been supplied for the Nordex N117 turbines (3.6 MW and 2.4 MW versions) that have been installed on the site. Review of the data confirmed that the noise emissions from the installed turbines on the Cleanrath site reach a maximum level at 7 m/s wind speed and do not increase at higher wind speeds.

Any increases in the overall measured noise level above rated power wind speed will typically be related to an increase in wind-generated noise (not associated with the Cleanrath turbines operation).

4.6 Summary

A summary of the approach taken is as follows:

- Derive the measured noise level under downwind conditions. This is done for night-time periods (in accordance with SGN 5 Section 2.4.4) as being subject to less influence from noise sources near the sound level meters (for example, activity at or nearby the house). The operational noise level contains noise from the wind farm but also a contribution from background noise such as wind-generated noise in foliage.
- If the measured noise level is less that the noise level limit, then the wind farm noise is deemed to be in compliance with the planning conditions at that location, without a requirement to adjust for background noise.
- If, however, the operational noise level is higher than the noise level limit then it is first necessary to subtract the contribution from background noise at that location and compare the results of that subtraction to noise level limits, in accordance with SGN 5 Section 2.4.8.

5.0 NOISE SURVEY RESULTS

Results at each of the noise survey locations are discussed in turn below.

5.1 Location C04

Survey personnel noted that turbine noise was audible at low level upon equipment set-up and during the various inspections for data downloading and battery changes. Other audible noise sources included wind generated noise on nearby foliage.

For the purposes of directional analysis, the downwind direction sector 190° to 295° has been considered at this location.

5.1.1 Cleanrath Operational Noise

The data included in Figure 5 relates to periods when, at a minimum, all primary turbines were operational.

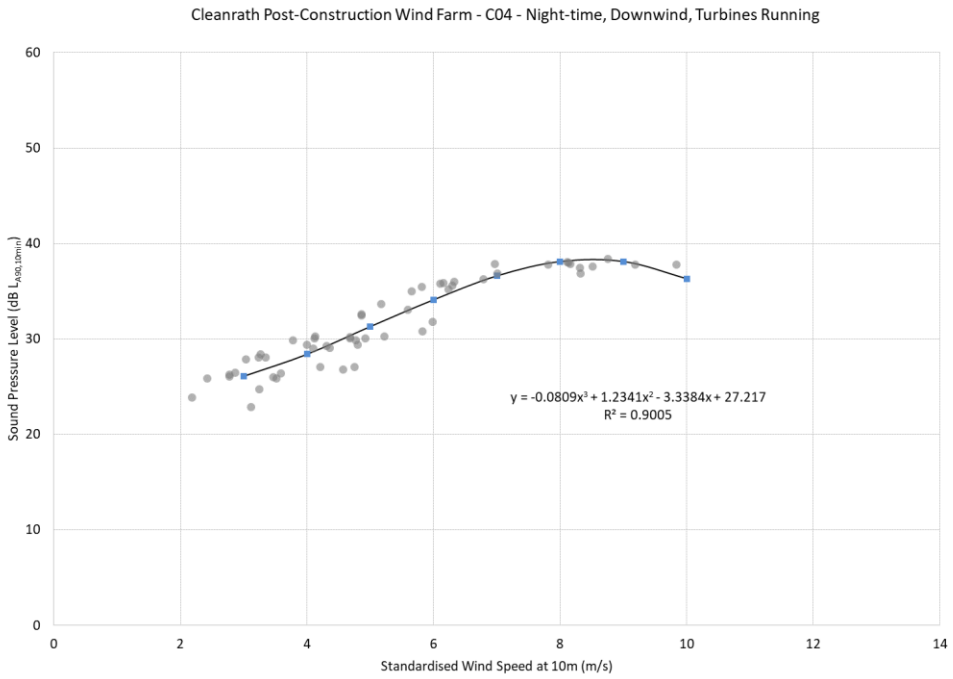


Figure 5 Location C04 – Directional Analysis – Cumulative Operational Periods

5.1.2 Discussion of Results

Table 7 outlines the measured noise levels at various wind speeds at Location C04.

Parameter	$L_{A90,10min}$ Levels (dB) at Standardised 10m Height Wind Speed (m/s)					
	3	4	5	6	7	8
Total measured noise (background + wind farm)	26.1	28.4	31.3	34.1	36.6	38.1
Noise Criterion	43	43	43	43	43	43
Complies?	✓	✓	✓	✓	✓	✓

Table 7 Measured Noise Levels at Location C04

In the first instance it is noted that the assessment is based on a conservative approach where the total measured noise level (i.e. background noise plus windfarm noise) rather than the wind turbine noise level in isolation. As can be seen, the operational noise level, i.e. turbine noise plus the background noise, is below the planning

condition limits, at all wind speeds. Therefore, the noise levels at C04 are in compliance with the relevant planning condition.

5.2 Location C18

Survey personnel noted that turbine noise was audible to varying degrees upon equipment set-up and during the various inspections, downloads and battery changes. Other audible noise sources included occasional local traffic, distant traffic, wind noise in nearby foliage and birdsong.

For the purposes of directional analysis, the downwind direction sector 90° to 200° has been considered at this location.

5.2.1 Cleanrath Operational Noise

The data included in Figure 6 relates to periods when, at a minimum, all primary turbines were operational.

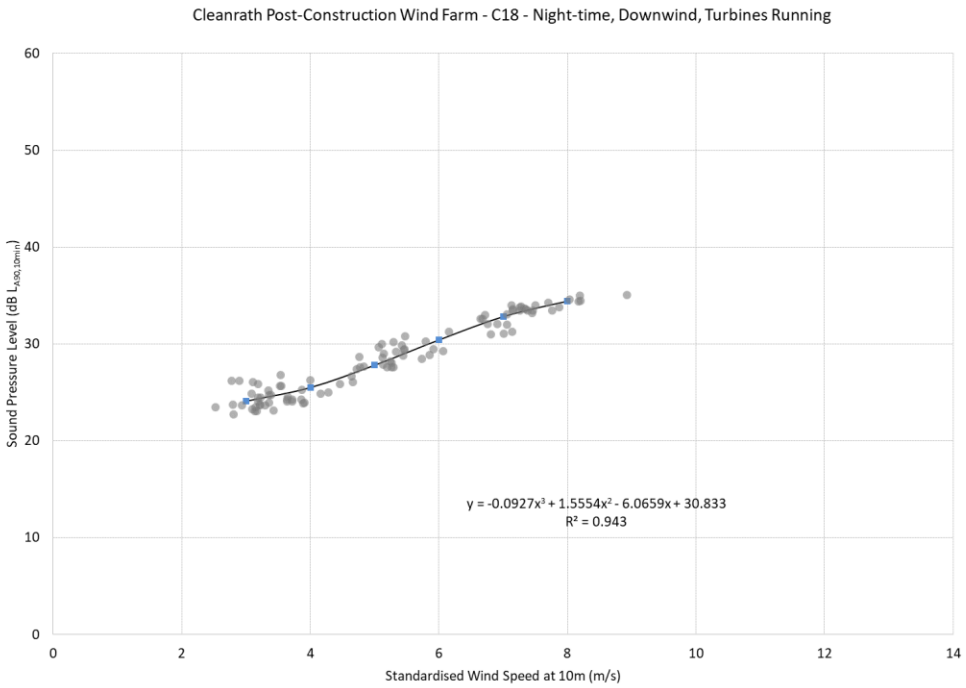


Figure 6 Location C18 – Directional Analysis – Cumulative Operational Periods

5.2.2 Discussion of Results

Table 8 outlines the measured noise levels at various wind speeds at location C18.

Parameter	$L_{A90,10min}$ Levels (dB) at Standardised 10m Height Wind Speed (m/s)					
	3	4	5	6	7	8
Total measured noise (background + wind farm)	24.1	25.5	27.8	30.4	32.8	34.4
Noise Criterion	43	43	43	43	43	43
Complies?	✓	✓	✓	✓	✓	✓

Table 8 Measured Noise Levels at Location C18

Similarly, the operational noise level is below the planning condition limits, even without considering the contribution from background noise to the levels in Table 7. Therefore, the noise levels at C18 are in compliance with the planning condition.

5.3 Location C23

Survey personnel noted that turbine noise was audible at low level upon equipment set-up and during the various inspections for data downloading and battery changes. Other audible noise sources included wind generated noise on nearby foliage.

For the purposes of directional analysis, the downwind direction sector (285° to 60°) has been considered at this location. In this instance, both day and night-time data was used in order to have sufficient samples across the wind speed range.

5.3.1 Cleanrath Operational Noise

The data included in Figure 7 relates to periods when, at a minimum, all primary turbines were operational.

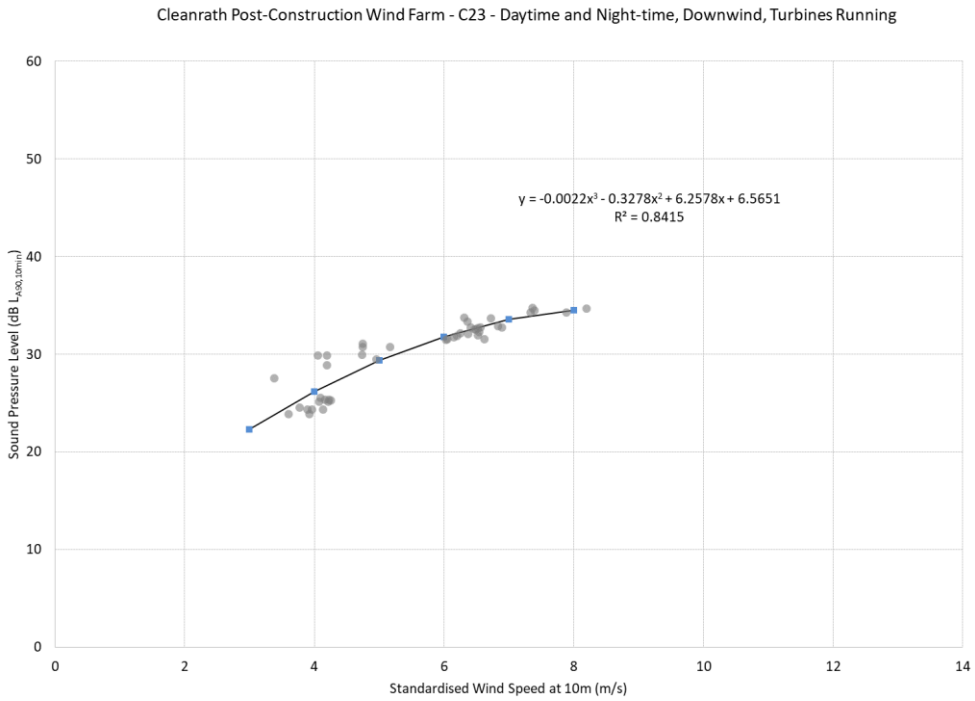


Figure 7 Location C23 – Directional Analysis – Cumulative Operational Periods

5.3.2 Discussion of Results

Table 9 outlines the measured noise levels at various wind speeds at location C23.

Parameter	$L_{A90,10min}$ Levels (dB) at Standardised 10m Height Wind Speed (m/s)					
	3	4	5	6	7	8
Total measured noise (background + wind farm)	22.3	26.2	29.4	31.8	33.6	34.5
Noise Criterion	43	43	43	43	43	43
Complies?	✓	✓	✓	✓	✓	✓

Table 9 Measured Noise Levels at Location C23

Once again, the operational noise level is below the planning condition, even without considering the contribution from background noise to the levels in Table 9. Therefore, the noise levels at C23 are in compliance with the planning condition.

6.0 CONCLUSION

The Cleanrath windfarm consists of nine Nordex N117 turbines with a hub height of 91m.

Table 10 provides a comparison of noise level associated with the Cleanrath wind turbines and the relevant noise criteria for each of the assessment locations for measurement locations C04, C18 and C23.

Loc.	Ref	dB L_{A90} at 10m standardised wind speed (m/s)					
		3	4	5	6	7	8
C04	Measured Cumulative Noise Level	26.1	28.4	31.3	34.1	36.6	38.1
	Noise Criterion	43	43	43	43	43	43
	Complies?	✓	✓	✓	✓	✓	✓
C18	Measured Cumulative Noise Level	24.1	25.5	27.8	30.4	32.8	34.4
	Noise Criterion	43	43	43	43	43	43
	Complies?	✓	✓	✓	✓	✓	✓
C23	Measured Cumulative Noise Level	22.3	26.2	29.4	31.8	33.6	34.5
	Noise Criterion	43	43	43	43	43	43
	Complies?	✓	✓	✓	✓	✓	✓

Table 10 Assessment of Compliance with Planning Condition

An assessment of the worst-case noise levels i.e. noise levels due to Cleanrath and Derragh wind farms along with other background noise sources, from the measured downwind data at each of the monitoring locations, in accordance with best practice contained within the IoA Good Practice Guide, has concluded that the relevant noise criteria have been complied in with each case.

APPENDIX A - GLOSSARY OF ACOUSTIC TERMINOLOGY

A variety of acoustic parameters and terminology are used throughout this report. Significant definitions are identified in this appendix in order to inform the reader.

A – Weighting	The "A" suffix denotes the fact that the sound levels have been "A-weighted" in order to account for the non-linear nature of human hearing.
Background Noise	The ambient noise level already present within the environment in the absence of the wind farm operation. The $L_{A90\ (10\ minutes)}$ is the parameter that is used to define the background noise level in this instance. L_{A90} is the sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise.
Daytime	Defined as 07:00 to 23:00hrs.
dB (decibel)	The scale in which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the RMS pressure of the sound field and the reference pressure of 20 micro-pascals (20 μPa).
dB(A)	An 'A-weighted decibel' – a measure of the overall noise level of sound across the audible frequency range (20 Hz – 20 kHz) with A-frequency weighting (i.e. A – Weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.
Hub Height Wind Speed	The wind speed at the centre of the turbine rotor.
L_{Aeq}	is the equivalent continuous sound level. It is a type of average and is used to describe a fluctuating noise in terms of a single noise level over the sample period.
L_{A90}	is the sound level that is exceeded for 90% of the sample period. It is typically used as a descriptor for background noise.
Night-time	Defined as 23:00 to 07:00hrs.
Noise	Noise is the term often used to describe unwanted sound (i.e. sound that annoys, interferes with activities or damages hearing). It is also used to describe a combination of sounds which vary randomly with time and which cover a wide frequency range.

APPENDIX A
Glossary of Terminology (Continued)

Noise Sensitive Location

Any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or other area of high amenity which for its proper enjoyment requires the absence of noise at nuisance levels.

Pascal (Pa)

Pascal is a unit of pressure and so sound pressures are measured in Pascals.

Sound Power Level (L_W)

The sound power level of an item is defined as:

$$L_p = 10 \times \log_{10}(W/W_o) \text{ dB.}$$

Where:

W is the acoustic power of the source in Watts(W)
W_o is a reference sound power chosen in air to be 10^{-12}W.

Sound Pressure Level (L_p)

The sound pressure level at a point is defined as:

$$L_p = 20 \times \log_{10}(P/P_o) \text{ dB.}$$

Where:

P is the sound pressure;
P_o is a reference pressure for propagation of sound in air and has a value of 2×10^{-5}Pa.

10 Minute Wind Speed (m/s)

The wind speed measured by a calibrated cup anemometer at a specified height above ground level, averaged over a 10 minute period.

APPENDIX B - CALIBRATION CERTIFICATES

(See Overleaf)

MEASUREMENT SYSTEMS

CERTIFICATE OF CALIBRATION

UKAS CALIBRATION
0653

Date of Issue: 06 August 2019 **Certificate Number: UCRT19/1874**

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Approved Signatory

J. Harriman

Customer
AWN Consulting
The Tecpro Building
IDA Business and Technology Park
Clonshaugh
Dublin 17

Order No. 1999

Description Sound Level Meter / Pre-amp / Microphone / Associated Calibrator

Identification

Manufacturer	*Instrument*	*Type*	*Serial No. / Version*
Rion	Sound Level Meter	NL-52	00575782
Rion	Firmware		2.0
Rion	Pre Amplifier	NH-25	65810
Rion	Microphone	UC-59	15093
Brüel & Kjær	Calibrator	4231	2460007
	Calibrator adaptor type if applicable		UC 0210

Performance Class 1

Test Procedure TP 2.SLM 61672-3 TPS-49
Procedures from IEC 61672-3:2006 were used to perform the periodic tests.

Type Approved to IEC 61672-1:2002 YES Approval Number 21.21 / 13.02
If YES above there is public evidence that the SLM has successfully completed the applicable pattern evaluation tests of IEC 61672-2:2003

Date Received 30 July 2019 ANV Job No. UKAS19/07502

Date Calibrated 06 August 2019

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1:2002.

Previous Certificate	*Dated*	*Certificate No.*	*Laboratory*
	28 July 2017	UCRT17/1628	0653

CERTIFICATE OF CALIBRATION

0653

Date of Issue: 22 August 2018 **Certificate Number: UCRT18/1866**

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Approved Signatory

K. Mistry

Customer	AWN Consulting Limited The Tecpro Building IDA Business and Technology Park Clonshaugh Dublin 17 Ireland
Order No.	PO1872
Description	Sound Level Meter / Pre-amp / Microphone / Associated Calibrator

Identification	*Manufacturer*	*Instrument*	*Type*	*Serial No. / Version*
	Rion	Sound Level Meter	NL-52	00564809
	Rion	Firmware		1.8
	Rion	Pre Amplifier	NH-25	64934
	Rion	Microphone	UC-59	09447
	Rion	Calibrator	NC-74	34536109
		Calibrator adaptor type if applicable		NC-74-002

Performance Class	1		
Test Procedure	TP 2.SLM 61672-3 TPS-49		
	Procedures from IEC 61672-3:2006 were used to perform the periodic tests.		
Type Approved to IEC 61672-1:2002	YES	Approval Number	21.21 / 13.02
	If YES above there is public evidence that the SLM has successfully completed the applicable pattern evaluation tests of IEC 61672-2:2003		
Date Received	17 August 2018	ANV Job No.	UKAS18/08534
Date Calibrated	22 August 2018		

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1:2002.

Previous Certificate	*Dated*	*Certificate No.*	*Laboratory*
	18 August 2016	UCRT16/1262	7623

CERTIFICATE OF CALIBRATION

0653

Date of Issue: 22 August 2018 **Certificate Number: UCRT18/1862**

Issued by:
ANV Measurement Systems
Beaufort Court
17 Roebuck Way
Milton Keynes MK5 8HL
Telephone 01908 642846 Fax 01908 642814
E-Mail: info@noise-and-vibration.co.uk
Web: www.noise-and-vibration.co.uk
Acoustics Noise and Vibration Ltd trading as ANV Measurement Systems

Approved Signatory

K. Mistry

Customer	AWN Consulting Limited The Tecpro Building IDA Business and Technology Park Clonshaugh Dublin 17 Ireland			
Order No.	PO1872			
Description	Sound Level Meter / Pre-amp / Microphone / Associated Calibrator			
Identification	*Manufacturer*	*Instrument*	*Type*	*Serial No. / Version*
	Rion	Sound Level Meter	NL-52	00564808
	Rion	Firmware		1.8
	Rion	Pre Amplifier	NH-25	64933
	Rion	Microphone	UC-59	09446
	Rion	Calibrator	NC-74	34536109
		Calibrator adaptor type if applicable		NC-74-002
Performance Class	1			
Test Procedure	TP 2.SLM 61672-3 TPS-49 *Procedures from IEC 61672-3:2006 were used to perform the periodic tests.*			
Type Approved to IEC 61672-1:2002	YES	Approval Number	21.21 / 13.02	
	If YES above there is public evidence that the SLM has successfully completed the applicable pattern evaluation tests of IEC 61672-2:2003			
Date Received	17 August 2018	ANV Job No.	UKAS18/08534	
Date Calibrated	22 August 2018			

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available, from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in IEC 61672-1:2002, the sound level meter submitted for testing conforms to the class 1 requirements of IEC 61672-1:2002.

Previous Certificate	*Dated*	*Certificate No.*	*Laboratory*
	18 August 2016	UCRT16/1263	7623

APPENDIX C – LIDAR INSTALLATION REPORT

(See Overleaf)

Zephir Campaign Device Installation Checklist

DISTRIBUTION :

Client:

Enerco Energy Ltd.

	Name	Job Title	Signature
Site Engineer	James Crowley	Design Engineer	
Prepared by	James Crowley	Design Engineer	
Reviewed by	James Crowley	Design Engineer	
Authorized by	Neil O'Brien	Project Engineer	
Date of Issue	01/04/2020	**Classification:**	Confidential

Client	Enerco Energy
Site name	Cleanrath
Project number	0040
Site information	
Deployment start date & time	27/04/2020 @ 13:49
Client contact details	James Crowley (+353) 86 3979248
Landowner contact details	Arranged by client
Site access procedure	Contact WFSO operational control number (+353) 21 7355898 before entering site and again when leaving site.
Site access route	Hardcore Surface to Unit from public road
Nearest town / Postcode	Macroom
Observed conditions	
Wind speed	Good wind. Between 5 & 7 m/s
Wind direction	Easterly
Precipitation	Sunny
Visibility	Clear
Deployment information	
Installation Engineer(s)	James Crowley
Model of device(s)	Zephir 300 (573)
Serial number of device(s)	
Location information	
Irish Grid coordinates	IG E119776, N69049
Elevation	**TBC**
Location description	Unit is located on a platform near Wind Farm roadway
Road Type	Hardcore Road Track
Distance from Access Road	You can drive within 3m of the Zephir

Vehicle Requirements	Car / Van	
Terrain Type	Rocky Mountainous area.	
Current Land use	Grazing	
Seasonal Land use (e.g. crops)	Grazing sheep. Forestry located North of the Zephir unit.	
Communications		
Router Hardware	Waltz software	
SIM Card Number	No SIM card	
SIM Card IP Address		
Signal strength (-dBm)		
Power supply		
Type	Turbine No.8	
Distance from Zephir (cable length)	275 m	
Fuel level		
Photos (including photo numbers)		
360° from North	Figure 1,2,3 & 4	
Ground conditions	Marginal Land.	
Others	See notes below	
Device configuration		
Alignment (offset from north)	Due North	
Scan type	VAD (Basic)	
Max Range	Met Station is positioned on an extension from the cage. Approx 1m above the cage. Clear Span around field is approx. 500m +	
VAD Processing	ON	~~OFF~~

Hourly Scanner Home	ON	~~OFF~~	
Hourly Window Wipe	ON	~~OFF~~	
Auto Clean	ON	~~OFF~~	~~NA~~
Heat up Before Start	ON	~~OFF~~	~~NA~~
Software version	Zephir Lidar ZP573		
Target description			
Distance to target	Living approx. 2km from unit		
Target coordinates			
Target elevation			
Settings File			
Segments			
Scan file			
Number of beams			
Azimuth	**Elevation``**		
Notes			

Zephir measurement heights set to:
10m, 28m, 43m, 53m, 68m, 80m, 89m, 98m, 113m, 138m

Site Description:
From the Zephir -
North – Ground rises gradually to top of rocky mountainous grass lands & forestry.
East – Ground rises through rocky mountain sheep grazing land.
South – Ground falls towards the village of Inchigeela – rocky mountainous sheep grazing land
West – Ground falls for a unknown distance through grazing ground into low lying re-planted forestry.
Note: Zephir is in a cage so therefore a **2m offset** approx. in reported heights vs. ground level set in software.

Photo’s

Figure 1 – Zephir from South looking North

Figure 2 – Zephir from North looking South

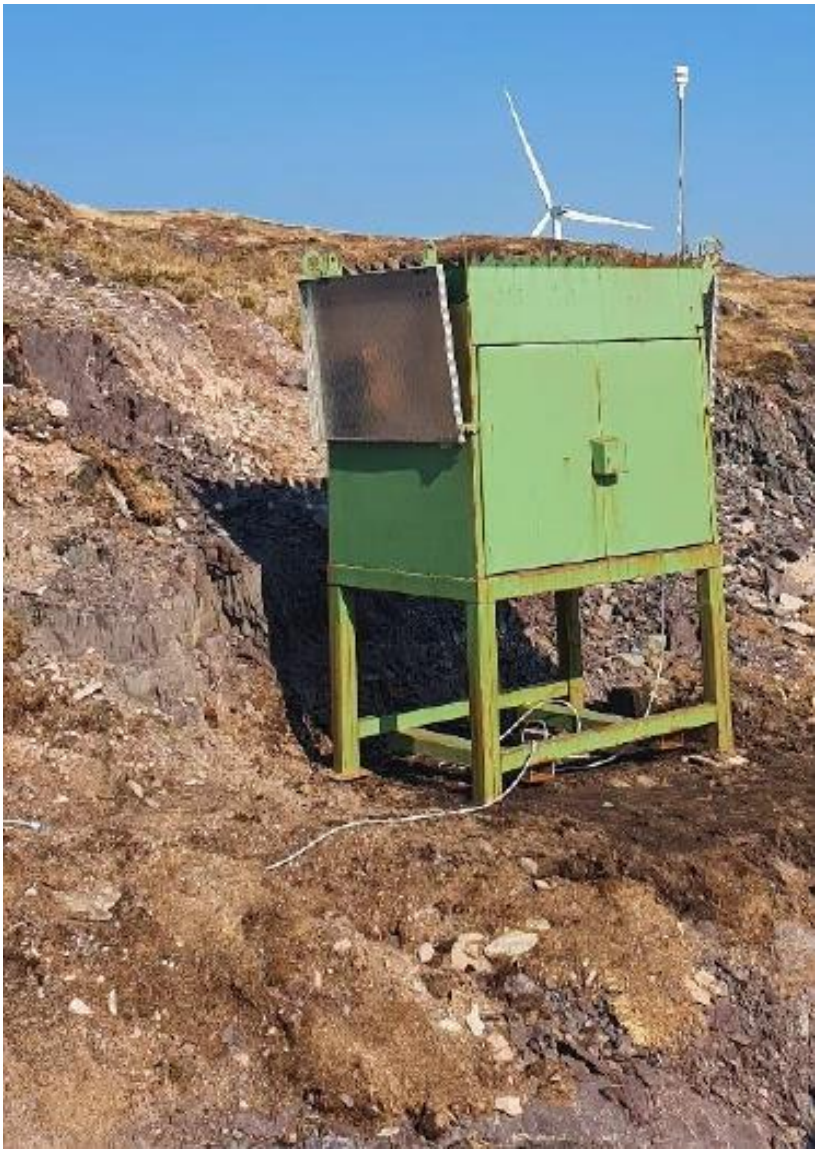
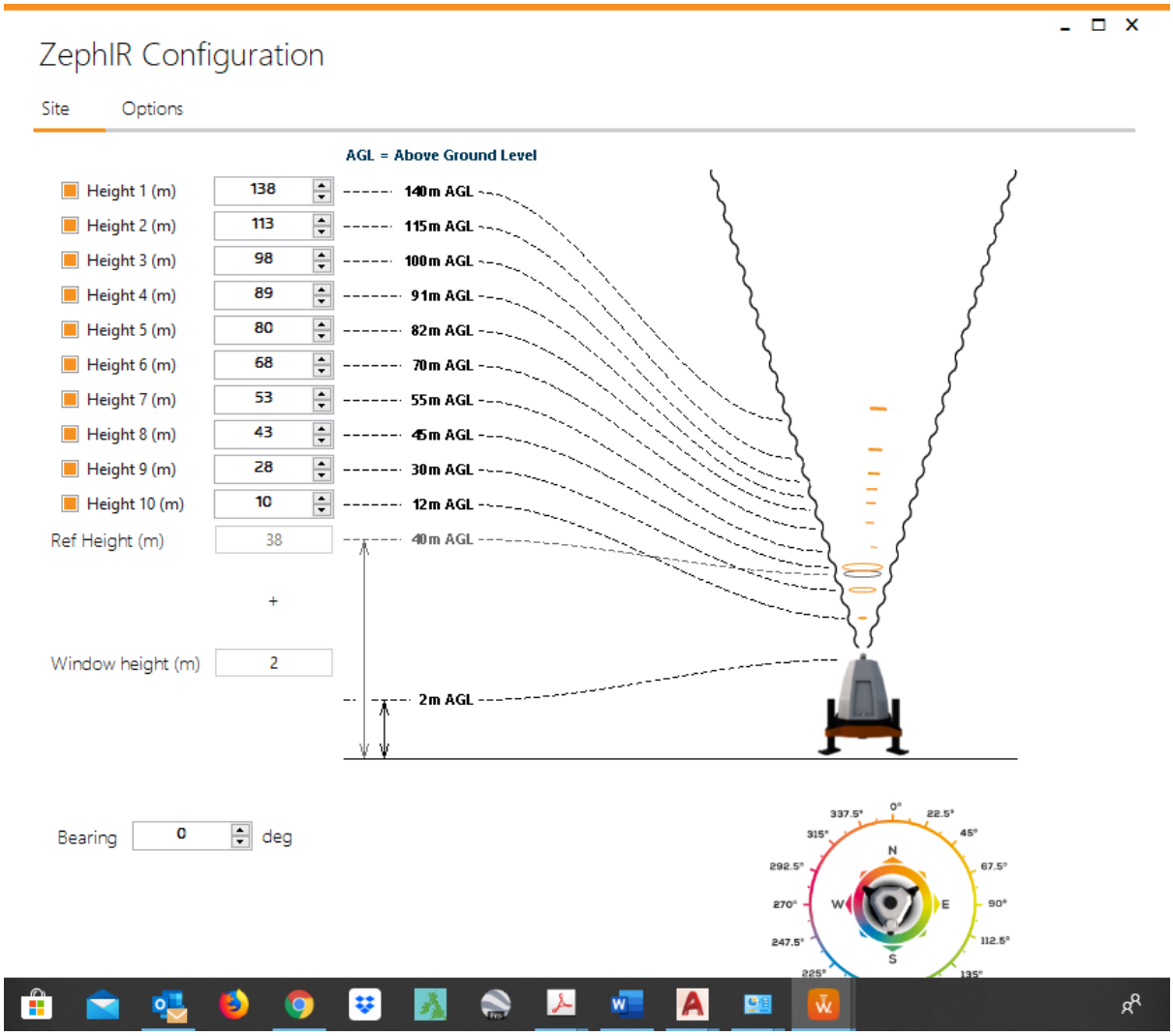


Figure 3 – Zephir from West facing East

Figure 4 – Zephir from East facing West


ZephIR Configuration
Site
Options
AGL = Above Ground Level
Height 1 (m) 138
Height 2 (m) 113
Height 3 (m) 98
Height 4 (m) 89
Height 5 (m) 80
Height 6 (m) 68
Height 7 (m) 53
Height 8 (m) 43
Height 9 (m) 28
Height 10 (m) 10
Ref Height (m) 38
+
Window height (m) 2
140m AGL
115m AGL
100m AGL
91m AGL
82m AGL
70m AGL
55m AGL
45m AGL
30m AGL
12m AGL
40m AGL
2m AGL
Bearing 0 deg
0°
22.5°
45°
67.5°
90°
112.5°
135°
157.5°
180°
202.5°
225°
247.5°
270°
292.5°
315°
337.5°
N
E
S
W