APPENDIX 11-6

NOISE MONITORING LOCATIONS

APPENDIX 11-6: NOISE MONITORING LOCATIONS

Note: The above diagram is not to scale and is for illustrative purposes only – exact co-ordinates of the locations are provided within Table 11-3 of Chapter 11.

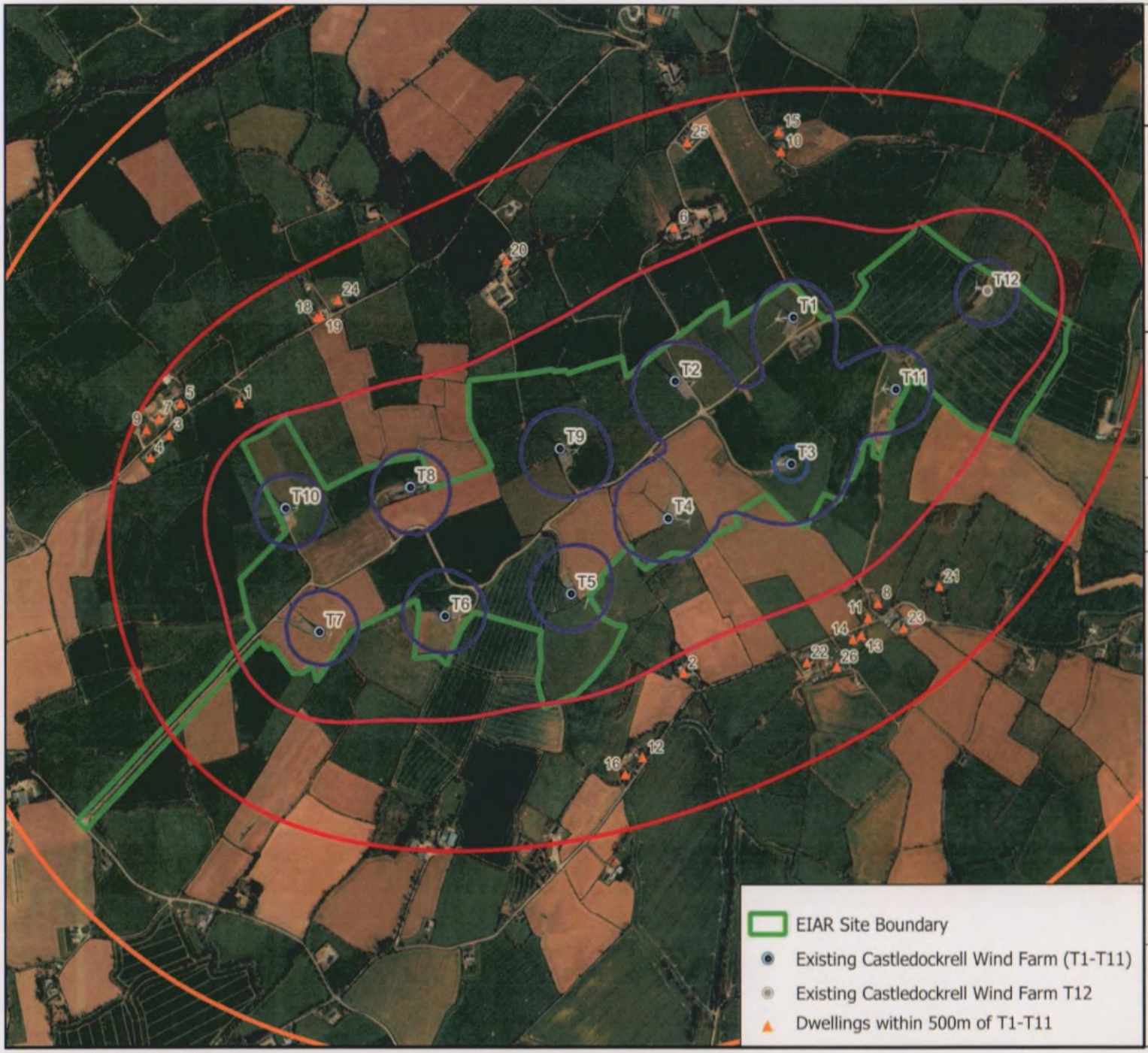
APPENDIX 11-7

NOISE SENSITIVE LOCATIONS

APPENDIX 11-7: NOISE SENSITIVE LOCATIONS

APPENDIX 11-8

NOISE LEVEL MAP



Customer: MKO
Project: Castledockrell WF
Project-No. 2024062

MKO

Map 1

Castledockrell Wind Farm

Enercon E70 wind turbines operating at 8m/s

Levels shown are LAeq, as per the WEDG19 LA90 = LAeq - 2dB

Project engineer: Dr Chris Jordan
Created: 03/09/2024
Processed with SoundPLAN 9.0, Update 19/06/2024

Levels LrD
in dB(A)

< 20	
20 - 25	
25 - 30	
30 - 35	
35 - 40	
40 - 45	
45 - 50	
50 - 55	
55 - 60	
>= 60	

Signs and symbols

- 3rd Party Buildings
- Switch Rooms
- Point receiver
- Inverters
- Industrial Sources
- Industrial building/Room
- Facade as source
- Outdoor area source
- Line source
- Wall
- Wall
- Noise calculation area

N

Length scale 1:16269

0 100 200 400 600 800 m

IRWIN CARR CONSULTING

C:\SoundPlan Jobs\Castledockrell WF\Sheet1.sgs

APPENDIX 11-9

SOUND POWER LEVEL DATA

APPENDIX 11-9: SOUND POWER LEVEL DATA

Exerts from Enercon E-70 E4 2300kW - Manufacturer's data sheet.

Tab. 6: Calculated sound power level in dB(A) based on wind speed at hub height

Wind speed at hub height (v_H)	Sound power level in dB(A)
5 m/s	86.7
5.5 m/s	88.6
6 m/s	90.5
6.5 m/s	92.4
7 m/s	94.3
7.5 m/s	96.6
8 m/s	98.8
8.5 m/s	99.8
9 m/s	100.7
9.5 m/s	101.3
10 m/s	101.8
10.5 m/s	102.6
11 m/s	103.4
11.5 m/s	103.7
12 m/s	104.0
12.5 m/s	104.2
13 m/s	104.3
13.5 m/s	104.4
14 m/s	104.5
14.5 m/s	104.5
15 m/s	104.5

3.3.1 Octave band level HH

Tab. 7: Octave band level in dB(A), based on wind speed v_H at hub height

v_H in m/s	Octave band level centre frequency in Hz								
	31.5	63	125	250	500	1000	2000	4000	8000
14	74.2	85.2	91.9	96.0	98.9	99.3	97.0	89.5	73.3

3.3.2 Octave band level E-70 EP2-ST-54-FB-C-01

Tab. 8: Octave band level in dB(A), based on standardised wind speed v_s at a height of 10 m

v_S at a height of 10 m in m/s	Octave band level centre frequency in Hz								
	31.5	63	125	250	500	1000	2000	4000	8000
9	74.8	85.8	92.6	97.0	99.6	98.7	95.3	89.5	76.9

APPENDIX 11-10

CUMULATIVE WIND FARM LIST

APPENDIX 11-10: POTENTIAL CUMULATIVE WIND FARMS

Table A-1 Potential cumulative wind farms

Wind Farm	X (ITM)	Y (ITM)	Distance to nearest turbine
Castledockrell – T12	692996.8	649806.9	331
Ballaman – T1	698675	653633	7291
Ballaman – T2	698609	653210	7017
Ballon Meats Turbine – T1	681114	664032	18022
Ballycadden – T1	699459.2	655997.8	9350
Ballycadden – T2	699449	656266.6	9525
Ballycadden – T3	699359	656508.4	9628
Ballycadden – T4	699725.8	656467.9	9865
Ballycadden – T5	699756.8	656793	10111
Ballycadden – T6	700062.7	656970.5	10454
Ballycadden – T7	700313.1	657276.2	10847
Ballycadden – T8	700211.6	657660.3	11046
Ballycadden – T9	700586.7	657701.1	11339
Ballynancoran – T1	699858.4	659434.9	12163
Ballynancoran – T2	699927.1	659038.7	11892
Bola More – T1	688593	648376	2795
Bola More – T2	688270	648516	3086
Bola More – T3	688356	648223	3061
Bola More – T4	688256	647916	3247
Bola More – T5	687920	647891	3573
Bola More – T6	688042	648184	3375
Gibbet Hill – T1	694327.6	658590	9030
Gibbet Hill – T2	694835.2	658779.4	9330
Gibbet Hill – T3	694441.2	658962.5	9418

Wind Farm	X (ITM)	Y (ITM)	Distance to nearest turbine
Gibbet Hill – T4	694727.3	659177.3	9690
Gibbet Hill – T5	696478.7	659480.8	10515
Gibbet Hill – T6	696215.5	659585	10516
Greenoge – T1	686394.1	656929.3	9176
Greenoge – T2	686181.3	657128.7	9460
Greenoge – T3	686023.2	657373.8	9752
Greenoge – T4	685663	657467.1	10036
Greenoge/Kilbrannish – T5	686286.6	656721.6	9066
Knockalour – T1	697871.8	660177.4	11731
Knockalour – T2	697481.2	659814.9	11231
Knockalour – T3	697453	660076	11454
Knockalour – T4	697061.7	659899.4	11129
Ballyduff – T1	702566.4	655801.9	11742
Ballyduff – T2	702756.6	656051.3	12034
Gorey Business Park – T1	714415.2	658528.3	23603
Cronelea Upper – T1	697600	671142.9	21996
Cronelea Upper – T2	697426.6	671327	22136
Cronelea Upper – T3	697823.1	671056.9	21965
Cronelea Upper 2 – T1	698051.7	670934.9	21903
Cronelea Upper 2 - T2	698305.9	670867.6	21904
Cronelea Upper 2 – T3	698381.5	670599.3	21666
Cronelea – T1	697421.3	670857.8	21677
Cronelea – T2	697281.5	670572.7	21368
Cronelea – T3	697507.6	670330.1	21184
Cronelea – T4	697208.8	670220.4	21008
Croaghan WF – T1	684518	658179	11295

Wind Farm	X (ITM)	Y (ITM)	Distance to nearest turbine
Croaghan WF – T2	684001	657497	11114
Croaghan WF – T3	683358	657224	11369
Croaghan WF – T4	684623	657755	10900
Croaghan WF – T5	683898	657163	10943
Croaghan WF – T6	685229	657672	10459
Croaghan WF – T6	684673	657299	10519

APPENDIX 11-11

NOISE MANAGEMENT PLAN

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CONSULTING

NOISE MANAGEMENT PLAN
CASTLEDOCKRELL WIND FARM, Co.WEXFORD

Rp002 2024062 (Castledockrell WF - Noise Management Plan)
22 October 2024

PROJECT: CASTLEDOCKRELL WIND FARM

PREPARED FOR: LANBER GROUP UNLIMITED COMPANY

1 THE COURTYARD

BROWNSWOOD

ENNISCORTHY

CO. WEXFORD

IRELAND

ATTENTION: CONOR KINSELLA

REPORT NO.: RP002 2024062

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Final	1.3	Issued to Client	22 October 2024	Shane Carr	Chris Jordan

TABLE OF CONTENTS

1.0 INTRODUCTION

Further to consultation with Wexford County Council, it was agreed that a Noise Management Plan would be submitted that addresses any noise complaints associated with Castledockrell Wind Farm, including consideration of Amplitude Modulation (AM) as necessary.

2.0 ASSESSMENT CRITERIA

2.1 IEC 61400-11

There has been a recent update to the Technical Specification IEC TS 61400-11[1] for the assessment of Wind Turbine Noise (WTN). The International Electrotechnical Commission (IEC) is a worldwide organisation for standardisation.

The introduction to the document states:

> *"The primary objective of this document is to establish uniform measurement and data analysis techniques to facilitate the evaluation of the A-weighted sound pressure level, or other acoustical properties, attributable to wind turbines at representative far-field locations. While this is a seemingly simple objective, wind turbines require wind to operate and the presence of wind complicates reliable acoustical measurements, either directly through wind induced microphone noise or indirectly through wind induced vegetative rustling sound. The presence of other common environmental sounds (planes, trains, road traffic, industrial, agricultural activities, etc.) can complicate or adversely influence the measured sound level. Owing to the distance of sound propagation, the meteorological conditions have a significant impact on the measurement results and the influence should be considered.*
>
> *Given that the regulatory requirements and history vary from country to country (and even within the same country), this document does not dictate regulatory metrics, but provides guidance on how best to isolate the sound attributable to wind turbines alone in the presence of other environmental sounds. It also provides guidance for those whose regulatory history for wind or other sources require the evaluation of specific acoustical aspects that have historically been subject to highly varying methodologies. Some countries have substantial experience with wind turbines while other countries are new to the special requirements of wind turbine sound measurements. Both can find guidance on how to standardise their approaches.*
>
> *In general, the document can be used by regulators and authorities, measurement laboratories, developers, operators and manufacturers for*
>
> - *comparison with local regulation;*
> - *comparison with guarantee values;*
> - *where no tradition for regulations of wind turbine sound immissions is available it can be used to aid the decision process;*
> - *assessment of the sound characteristics in wind turbine sound as well as the sound level."*

The document goes on to provide detail in relation how noise measurements should be carried out, the range of environmental data to be collected and the final paragraph of the Scope of the documents states:

> *"This document is not restricted to wind turbines of a particular size or type. The procedures described in this document allow for the thorough description of the sound characteristics and sound immissions from wind turbines."*

Section 13 of the IEC 61400-11:2024 identifies the Institute of Acoustics Amplitude Modulation (IOA AM) Working Group Reference Method as being implemented within the document due to:

> *NOTE This method has been identified for inclusion at the time of publication given its robust development and successful deployment history. It is understood that other methods are under development.*

[1] IEC TS 61400-11-2:2024 Wind energy generation systems – Part 11-2: Acoustic noise measurement techniques – Measurement of wind turbine sound characteristics in receptor position

2.2 Institute of Acoustics Reference Method

Amplitude Modulation has been defined by the IOA AMWG[2] in their final report as:

> *"Wind turbine amplitude modulation is defined as periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency[3] of the turbine rotor(s)."*

This Institute of Acoustics (IoA) document goes on to say AM should be assessed externally:

> *The assessment procedure and metric are intended to be applied to external measurements of noise experienced at locations at 'residential distances', separation distances between large wind turbines and dwellings in the UK being typically 500 metres or greater. The procedure is based on outdoor measurements in the vicinity of dwellings, primarily because of the practical difficulties associated with making repeatable noise measurements indoors. Reliance on external measurements is consistent with established standards and procedures for assessing environmental noise*

The IOA provide a Reference Method (IOA RM) for defining AM, this RM involves the following stages:

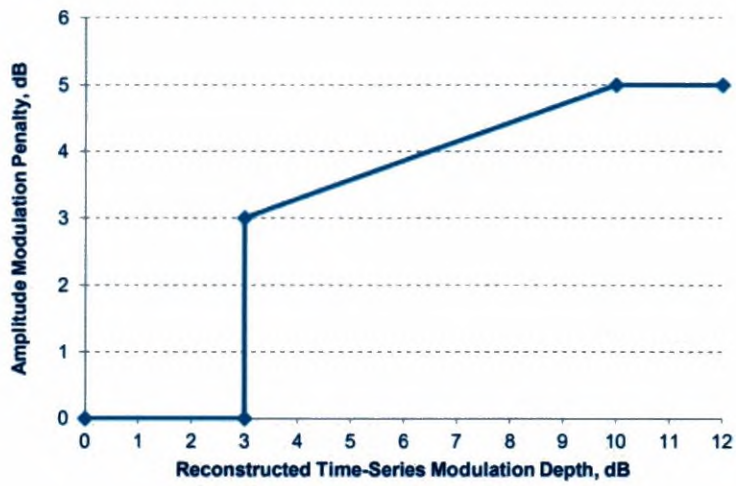
- Noise is measured in short-term, 100-millisecond LAeq values in 1/3-octave bands. Three frequency ranges or bands are evaluated: 50-200 Hz; 100-400 Hz and 200-800 Hz, and the results which exhibit the highest resulting levels of AM are used
- The fundamental length of input sample to be assessed (the minor time interval) is 10 seconds
- The hybrid reconstruction method is used to determine the AM value for each 10 second value
- The values of AM measured by the metric in each 10-second interval are aggregated over a 10-minute period (the major time interval) to provide a single value which is the AM rating for the 10-minute period.

This AM rating is not the penalty to be applied by simply a representation of the peak to trough of the noise signal.

2.3 Wind Turbine AM Review

The Phase 2 report[4] builds on the IOA RM by taking the AM rating value (also known as "Reconstructed Time-Series Modulation Depth, dB") and using this to determine a penalty for amplitude modulation within the measured noise levels. Figure 1 below presents the penalty to be applied to the associated Reconstructed Time-Series Modulation Depth.

Figure 1: Proposed Penalty Scheme



[2] Institute of Acoustics Amplitude Working Group, Final Report 9 August 2016
[3] Blade Passing frequency (Hz) = (Rotor RPM) x (No. of blades)/60
[4] Wind Turbine AM Review, Phase 2 Report, Department of Energy & Climate Change, Aug 2016

2.4 Wind Energy Development Guidelines 2006

The Wind Energy Development Guidelines 2006 (WEDG06) are the existing guidelines for assessing wind turbine noise levels in Ireland. The following are a number of key extracts from the 2006 Guidelines in relation to noise impact:

> General Noise Impact
>
> *"Noise impact should be assessed by reference to the nature and character of noise sensitive locations."*
>
> *"Separate noise limits should apply for day-time and for night-time"*
>
> *"Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed."*
>
> Measurement Units
>
> *"The descriptor [$L_{A90,10min}$] which allows reliable measurements to be made without corruption from relatively loud transitory noise events from other sources, should be used for assessing both wind energy development noise and background noise."*
>
> Specific Noise Limits
>
> *"Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed."*
>
> *"In general, a lower fixed limit of 45 dB(A) or a maximum increase of 5 dB(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 the margin of 5 dB(A) above the background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments. Instead in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of $L_{A90,10min}$ of the wind energy development noise should be limited to an absolute level within the range 35-40 dB(A)".*
>
> *"During the night the protection of external amenity becomes less important and the emphasis should be on preventing sleep disturbance. A fixed limit of 43 dB(A) will protect sleep inside properties during the night"*

The 2006 Guidelines do not specify daytime or night-time hours. However, it is considered good practice to follow the framework given in ETSU-R-97 and IOA Good Practice Guide where daytime and night-time hours are specified. The limits are based on the prevailing background noise level for 'quiet daytime' periods, defined in ETSU-R-97 as:

- Quiet waking hours or quiet day-time periods are defined as:

  All evenings from 18:00 to 23:00hrs

  Saturday afternoon from 13:00 to 18.00hrs and all-day Sunday 07:00 to 18:00hrs

- Night-time is defined as 23:00 to 07:00hrs

2.5 Institute of Acoustics Good Practice Guide – May 2013

The Institute of Acoustics Noise Working Group were tasked with providing a Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise in relation to how noise impacts are considered in relation to wind energy developments. A number of Supplementary Guidance Notes support the Good Practice Guide with SGN 5: 'Post Completion Measurements' providing specific direction on compliance monitoring.

Various aspects of the compliance monitoring were addressed in this document, including:

- Noise Limits in Planning Conditions;
- Measurement of Wind Speed;
- Measurement Locations and Instrumentation;
- Noise Data and Data Processing;
- Outcome of Measurement Exercise.

The requirements of this document have been incorporated into the compliance measurement methodology to ensure that the measurement methodology was conducted in line with what is considered good practice.

3.0 MEASUREMENT LOCATIONS AND INSTRUMENTATION

A noise level meter will be deployed at the complainant's property to be representative of the wind farm noise impacts upon the dwelling, whilst attempting to minimise the influence from background noise levels (i.e. placing the noise level meter on the side of the dwelling facing the wind farm). Noise levels will be recorded in both L_{A90} 10 minute and L_{Aeq} 1/3 octave 100 millisecond periods.

Rainfall will be measured using a rain gauge, set adjacent to the noise level meter, recording average rain fall levels in millimetres over consecutive 10 minute periods.

Hub height wind speed and direction data will be provided by the wind farm operator (in metre per second and degrees) over consecutive 10 minute periods. The wind speed and wind direction across all the wind farm turbines will be averaged for each 10 minute period (or if a specific turbine/s requires consideration wind speeds and directions will be tailored to specific turbines). Hub height wind speeds will be converted to 10m height standardised wind speeds using the formula in Figure 2.

Figure 2: Standardisation of wind speeds formula

Shear exponent profile:	this uses the following equation: $U = U_{ref} \cdot \left[\frac{H}{H_{ref}}\right]^{m}$
	Where:
	U calculated wind speed.
	U_{ref} measured wind speed
	H height at which the wind speed will be calculated
	H_{ref} height at which the wind speed is measured
	m shear exponent = $\log(U/U_{ref})/\log(H/H_{ref})$

. The following data processing will be undertaken:

- The relationship between measured ambient noise levels and wind data will be determined
- All periods of rainfall will be filtered out.
- Only data between 23:00 to 04:00 will be included, reducing the likelihood of extraneous noise sources affecting data (e.g. early morning birdsong and traffic).
- Only data within 45 degrees either side of directly downwind for the monitoring location/s will be included. It should be noted that, downwind may be present across a number of wind directions given the breadth of the wind farm, therefore expanding the potential 'arc' of included data.
- Other wind directions and times will be considered if a specific complaint arises further to complainant logs identified repeated concerns
- Measurements will be corrected for the influence of background noise levels (as previously presented within documentation submitted in support of the planning application) by subtracting the background noise level in the manner prescribed in page 88 of ETSU-R-97.
- Any penalties for Amplitude Modulation will be added to the corrected operational noise levels for each 10 minute period, as per the method described in Section 2.

Depending on the location of the complainant's property relative to the wind farm, it may be the case that achievement of a downwind scenario is rare and therefore extended monitoring may be necessary. Typically 6 weeks or monitoring is required, though this may need to be extended depending on wind conditions during the monitoring period.

2.6 Proxy noise level monitor - Optional

It may be the case that further to undertaking monitoring that background noise level influence is so significant that it is difficult to determine noise levels solely from the wind farm. In such cases, additional concurrent noise level monitoring may be necessary, with an additional noise level monitor in close proximity to the wind farm, such that the dominant noise source at the proxy location is wind farm noise. The proxy location noise level data could then be used to 'calibrate' a noise level model to determine noise levels at the complainant's property.

However, proxy noise level measurement locations can not be used to determine amplitude modulation penalties and therefore it will still be necessary to measure noise levels at the receptor location, concurrently.

4.0 NOISE DATA AND DATA PROCESSING

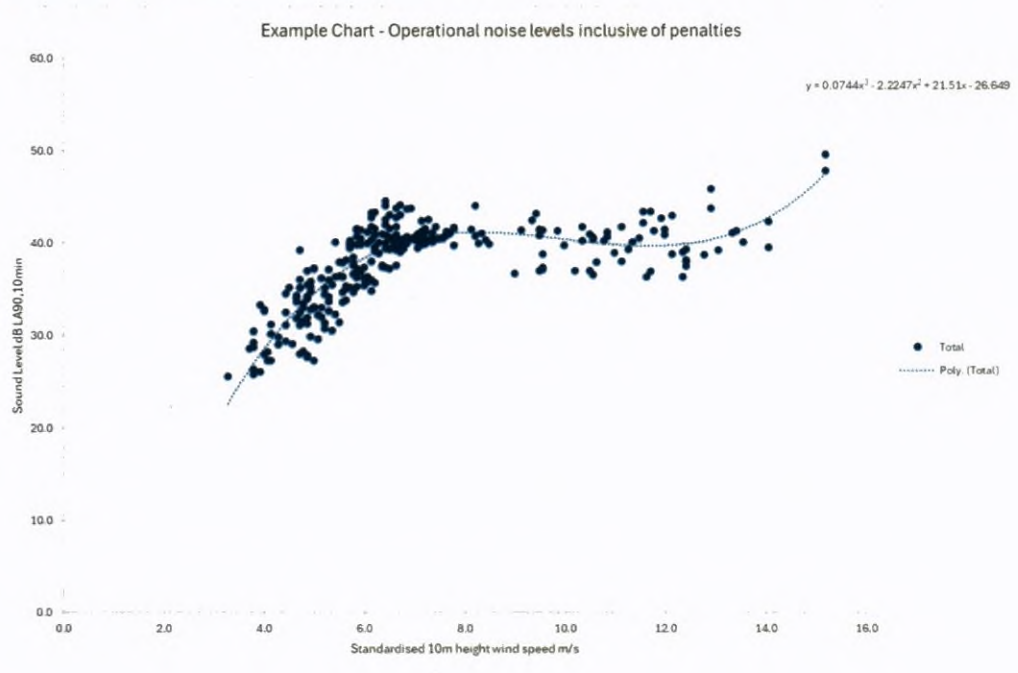
Data analysis will be conducted on the noise measurement data:

- Only data where the wind farm was operational will be included
- Only data between the hours of 23:00 and 04:00 will be included
- Only data within 45 degrees either side of directly downwind of the monitoring location will be included.
- Other wind directions and times will be considered if a specific complaint arises further to complainant logs identified repeated concerns
- Only data where rainfall was not registered will be included

Taking into consideration the above exclusions, the remaining data set will be plotted on a chart of wind speed against operational noise level (inclusive of any penalties).

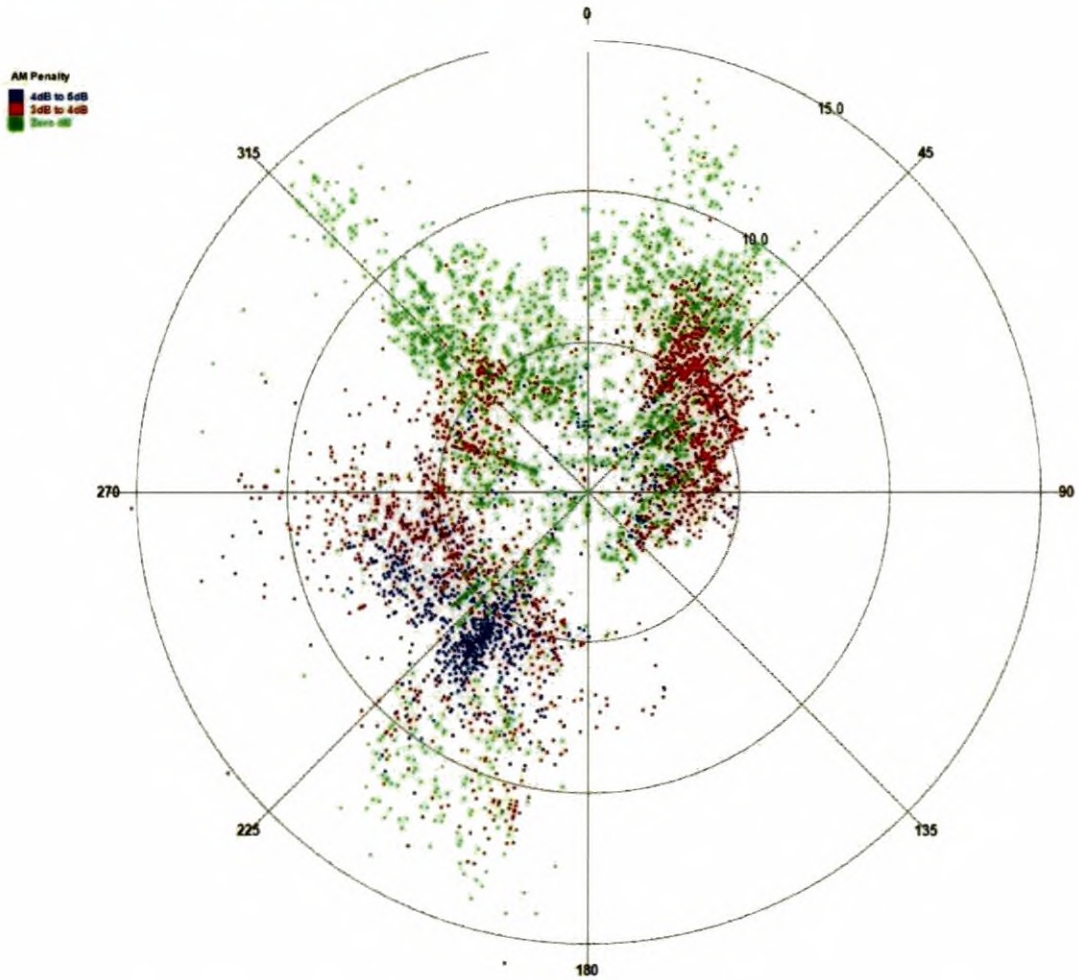
The best fit polynomial line for the chart will then be used to derive the operational noise levels (inclusive of any penalties) between the wind speeds of 4 to 12m/s wind speeds. An example is provided in Figure 3:

Figure 2: Example operational noise level chart



In addition, a windrose plot will be provided presenting any penalties for Amplitude Modulation across all wind speeds and directions to assist in identifying any particular wind speeds or directions that present increased levels of Amplitude Modulation. An example is provided in Figure 4:

Figure 4: Windrose operational noise level chart



Finally, the total measured noise levels inclusive of any penalties will be compared against the background noise level +5dB(A) limit or limits as included within any grant of permission by Wexford County Council.

If noise levels are in excess of the background noise level +5dB(A) limit at the complainant's property, a curtailment strategy will be designed to ensure that noise levels from wind farm will reduce either absolute noise levels or reduce the presence of Amplitude Modulation (or a combination of both). Further to the curtailment strategy being initiated, additional noise level monitoring will be undertaken as above to determine the successfulness of the curtailment strategy in reducing operational noise levels to under the background noise level +5 dB(A) limit. Repeated improvements to the curtailment strategy and remeasurement will continue until operational noise levels are under the background noise level +5 dB(A) limit.

APPENDIX A

Ambient	The ambient noise level is the noise level measured in the absence of the intrusive noise or the noise requiring control. Ambient noise levels are frequently measured to determine the situation prior to the addition of a new noise source.
dB	Decibel. The unit of sound level.
dBA	A-weighted decibel. The A-weighting approximates the response of the human ear.
Frequency	Sound can occur over a range of frequencies extending from the very low, such as the rumble of thunder, up to the very high such as the crash of cymbals. Sound is generally described over the frequency range from 63Hz to 4000Hz (4kHz). This is roughly equal to the range of frequencies on a piano.
Octave band	Sound, which can occur over a range of frequencies, may be divided into octave bands for analysis. The audible frequency range is generally divided into 7 octave bands. The octave band frequencies are 63Hz, 125Hz, 250Hz, 1kHz, 2kHz and 4kHz.
$L_{Aeq\,(t)}$	The equivalent continuous (time-averaged) A-weighted sound level. This is commonly referred to as the average noise level. The suffix "t" represents the time period to which the noise level relates, e.g. (8 h) would represent a period of 8 hours, (10 min) would represent a period of 10 minutes and (2200-0700) would represent a measurement time between 10 pm and 7 am.
L_{90}	The noise level exceeded for 90% of the measurement period. This is commonly used to measure wind turbine and background noise levels.

APPENDIX 11-12

NOISE ASSESSMENT – AMPLITUDE MODULATION

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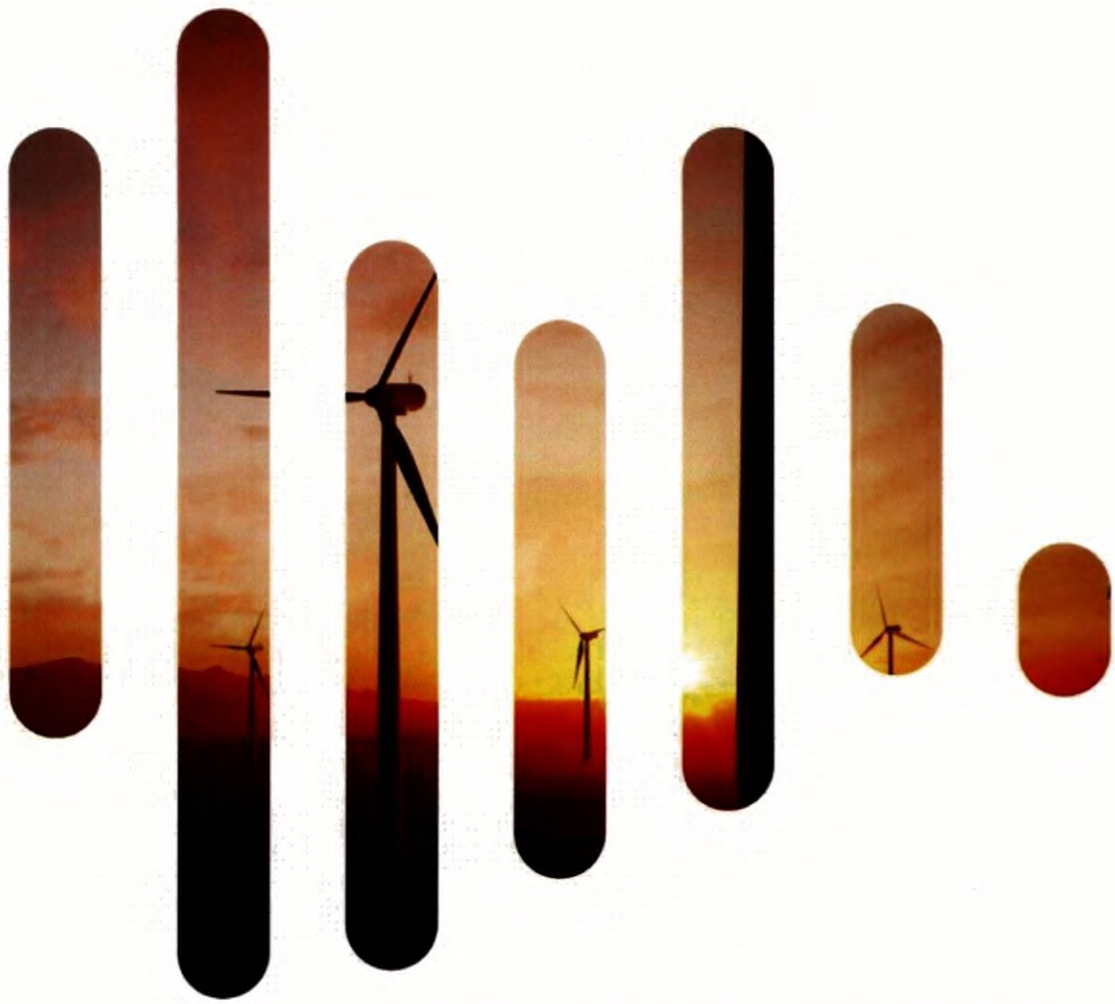

AMPLITUDE MODULATION - NOISE ASSESSMENT
CASTLEDOCKRELL WIND FARM, CO.WEXFORD

Rp001N 2025020 (Castledockrell AM)
3 March 2025

PROJECT: CASTLEDOCKRELL WIND FARM – AMPLITUDE MODULATION

PREPARED FOR: LANBER GROUP

1 THE COURTYARD

BROWNSWOOD

ENNISCORTHY

CO WEXFORD

Y21 F291

ATTENTION: CONOR KINSELLA

REPORT NO.: RP 001 2025020

Document Control

Status:	Rev:	Comments	Date:	Author:	Reviewer:
Final	1.1	Issued to Client	3 March 2025	Chris Jordan	Shane Carr

TABLE OF CONTENTS

1.0 INTRODUCTION

Irwin Carr has undertaken noise measurements with respect to Castledockrell Wind Farm to assess the noise impact from the operation of the site at specific receptor locations.

Noise level measurements were undertaken at three locations representing neighbouring dwellings to the east of Castledockrell Wind Farm, thus maximising worst case downwind conditions due to the predominant south westerly winds present in Ireland.

This noise assessment considers the overall noise levels for comparison with the planning permission and WEDG06 as well as assessing an applicable penalty for the present of Amplitude Modulation (AM).

Acoustic terminology used throughout this report is described in Appendix A.

2.0 ASSESSMENT CRITERIA

The most recent published document in relation to wind turbine noise is the new IEC Technical Specification (IEC TS 61400-11-2:2024, Acoustic noise measurement techniques, Measurement of wind turbine sound characteristics in receptor position).

As detailed below this new IEC:

- Implements the Institute of Acoustics Reference Method (IOA RM) for quantifying AM
- Uses the penalties in the WSP/ Parsons Brinckerhoff Phase 2 report as the required adjustments to Wind Turbine Noise (WTN) noise levels to take account of AM levels

For the purpose of quantifying the impact of WTN and AM at the nearby residential properties, noise measurements were undertaken in line with the Institute of Acoustics Good Practice Guide (IOA GPG) in relation to compliance monitoring for wind turbines and used the new IEC61400-11 to

A. quantify the level of AM and

B. to then apply the appropriate AM penalties to the measured levels.

For the avoidance of any doubt, the AM penalty scheme set out in the new IEC TS 61400-11 is the same as the AM penalty scheme stipulated in the Draft 2019 WEDG.

This methodology was relied upon to compare a rated turbine noise level (measured L_{A90} plus penalty) to the standards in the exiting documents.

Further details of each standard relied upon are presented below.

Planning Permission

The original 11-turbine Castledockrell Wind Farm (i.e. the Proposed Development) was granted planning permission by Wexford County Council on 16th March 2005 (Planning Permission 20044702), which was subsequently appealed to An Bord Pleanála and permitted in 2005 under Planning Reference PL26.211725. The ABP decision does not include any planning conditions with respect to noise limits and thus the Proposed Development is not currently bound to any noise limits. The additional 12th turbine was permitted under Planning Permission 20080335) as granted by Wexford County Council on 2nd April 2008.

Whilst the Proposed Development is not currently bound to any noise limits, it is noted that Wexford County Council recommended noise limits in the form of Condition 8.

Condition 8 of planning permission 20044702 states,

> *'Maximum noise levels at the nearest noise sensitive properties shall be:*
>
> *a) 40dB(A) L_{Aeq}., at a wind speed of 5 metres per second at hub height of nearest machine*

b) 45dB(A) L_{Aeq}., at a wind speed of 8 metres per second at hub height of nearest machine;

In the event that the review/monitoring of the development shows that any turbine may be having detrimental noise impact, mitigating measures shall be proposed and submitted for the agreement of the Planning Authority.

REASON:

In the interests of residential amenity and the proper planning and sustainable development of the area.'

It should be noted that the current consensus in measuring wind energy noise levels is L_{A90} as opposed to L_{Aeq}.

ETSU-R-97 page 58 states, "...the Noise Working Group is agreed that the L_{A90} descriptor should be used for both the background noise and the wind farm noise and that when setting limits it should be borne in mind that the L_{A90} of the wind farm is likely to be about 1.5 – 2.5dB(A) less than the L_{Aeq} measured over the same period."

The IOA Good Practice Guide furthers the above by stating in paragraph 4.2.5, "The source sound power levels determined according to IEC 61400-11 are provided in terms of L_{Aeq}. To obtain the L_{A90} parameter required by ETSU-R-97, it is necessary to apply a correction to the prediction results. Based on the experience of the IOA-NWG and recent research, the assumption described in ETSU-R-97 in this regard continues to remain valid. A correction of -2 dB is commonly applied."

Thus applying a 2dB conversion factor between the two measurement parameters (i.e. L_{A90} = L_{Aeq}-2dB), the recommended Condition 8 noise limits when converted to L_{A90} equate to:

"a) 38dB(A) LA90., at a wind speed of 5 metres per second at hub height of nearest machine
b) 43dB(A) LA90., at a wind speed of 8 metres per second at hub height of nearest machine;"

2.1 Wind Energy Development Guidelines 2006

The following are a number of key extracts from the 2006 Guidelines in relation to noise impact:

General Noise Impact

"Noise impact should be assessed by reference to the nature and character of noise sensitive locations."

"Separate noise limits should apply for day-time and for night-time"

"Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed."

Measurement Units

"The descriptor [LA90,10min] which allows reliable measurements to be made without corruption from relatively loud transitory noise events from other sources, should be used for assessing both wind energy development noise and background noise."

Specific Noise Limits

"Noise limits should be applied to external locations and should reflect the variation in both turbine source noise and background noise with wind speed."

"In general, a lower fixed limit of 45 dB(A) or a maximum increase of 5 dB(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 the margin of 5 dB(A) above the background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments. Instead in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of $L_{A90,10min}$ of the wind energy development noise should be limited to an absolute level within the range 35-40 dB(A)".

"During the night the protection of external amenity becomes less important and the emphasis should be on preventing sleep disturbance. A fixed limit of 43 dB(A) will protect sleep inside properties during the night"

The 2006 Guidelines do not specify daytime or night-time hours. However, it is considered good practice to follow the framework given in ETSU-R-97 and IOA Good Practice Guide where daytime and night-time hours are specified. The limits are based on the prevailing background noise level for 'quiet daytime' periods, defined in ETSU-R-97 as:

- Quiet waking hours or quiet day-time periods are defined as:

  All evenings from 18:00 to 23:00hrs

  Saturday afternoon from 13:00 to 18.00hrs and all-day Sunday 07:00 to 18:00hrs

- Night-time is defined as 23:00 to 07:00hrs

2.2 IEC 61400-11

The specified sound power levels associated with wind turbines has been based on the IEC 61400 standard. Part 11 relates to the Acoustic noise measurement techniques and had been the bases of manufacturers data for noise with all turbines.

The updated Technical Specification IEC TS 61400-11[1] for the assessment of Wind Turbine Noise (WTN) was published in March 2024. The International Electrotechnical Commission (IEC) is a worldwide organisation for standardisation and the updated document presents measurement procedures that enable the sound characteristics of a wind turbine to be determined at receptor (immission) locations. Importantly, the new updated IEC TS 61400-11 now also covers AM.

The National Standards Authority of Ireland (NSAI) are the Irish representatives to the IEC. The NSAI website identifies the IEC as an international standardisation body which adopts international standards. The IEC TS 61400-11-2 has been adopted by the IEC.

As per the scope of the document, the measurement procedures **are specific to wind turbine noise**, with the document stating:

The procedures described are different in some respects from those that would be used for noise assessment from other industrial sound sources in environmental noise impact assessments. They are intended to facilitate characterization of wind turbine sound with respect to a range of wind speeds and directions.

The introduction to the document states:

[1] IEC TS 61400-11-2:2024 Wind energy generation systems – Part 11-2: Acoustic noise measurement techniques – Measurement of wind turbine sound characteristics in receptor position

"The primary objective of this document is to establish uniform measurement and data analysis techniques to facilitate the evaluation of the A-weighted sound pressure level, or other acoustical properties, attributable to wind turbines at representative far-field locations. While this is a seemingly simple objective, wind turbines require wind to operate and the presence of wind complicates reliable acoustical measurements, either directly through wind induced microphone noise or indirectly through wind induced vegetative rustling sound. The presence of other common environmental sounds (planes, trains, road traffic, industrial, agricultural activities, etc.) can complicate or adversely influence the measured sound level. Owing to the distance of sound propagation, the meteorological conditions have a significant impact on the measurement results and the influence should be considered.

Given that the regulatory requirements and history vary from country to country (and even within the same country), this document does not dictate regulatory metrics but provides guidance on how best to isolate the sound attributable to wind turbines alone in the presence of other environmental sounds. It also provides guidance for those whose regulatory history for wind or other sources require the evaluation of specific acoustical aspects that have historically been subject to highly varying methodologies. Some countries have substantial experience with wind turbines while other countries are new to the special requirements of wind turbine sound measurements. Both can find guidance on how to standardise their approaches.

In general, the document can be used by regulators and authorities, measurement laboratories, developers, operators and manufacturers for

- *comparison with local regulation;*
- *comparison with guarantee values;*
- *where no tradition for regulations of wind turbine sound immissions is available it can be used to aid the decision process;*
- *assessment of the sound characteristics in wind turbine sound as well as the sound level."*

The document goes on to provide detail in relation to how noise measurements should be carried out, the range of environmental data to be collected and the final paragraph of the Scope of the document states:

"This document is not restricted to wind turbines of a particular size or type. The procedures described in this document allow for the thorough description of the sound characteristics and sound immissions from wind turbines."

Section 13 of the IEC 61400-11:2024 deals with AM and identifies the IoA AM Working Group Reference Method as the chosen AM assessment methodology together with the following explanatory note:

NOTE This method has been identified for inclusion at the time of publication given its robust development and successful deployment history. It is understood that other methods are under development.

As per the note above, other methods are acknowledged as being under development, but no further reliance has been given to them. At the time of publication of the new IEC, 27 March 2024, the IoA AM Working Group Reference Method ["IOA RM"] is acknowledged in the new IEC as the most robust methodology for assessing AM and it is also recognised that the IOA RM has had a successful deployment history.

In the definition section of the new IEC 61400-11:2024, it defines AM at section 3.22 within the document as:

amplitude modulation: regular fluctuation in the level of sound, the period of fluctuations being related to the rotational speed of the wind turbine

Note 1 to entry: This characteristic might be described by a listener as a repetitive 'swish', 'whoomph' or 'thump'.

This definition includes **both** of the categories of wind turbine AM as identified, so the updated IEC and associated methodology cover all of the definitions of AM.

Annex A of the new IEC of 27 March 2024 provides guidance on the Rating level applicable to AM. At Section A.3, it provides a similar adjustment as shown in Figure 1 below from the WSP/ Parsons Brinckerhoff Phase 2 report (this is also the AM penalty scheme that was stipulated in the Draft WEDG 2019).

The AM penalty scheme which has been set out in Figure A.1 of Annex A.3 of the new IEC of 27 March 2024 is to be applied to both of the categories of wind turbine AM, so the AM penalty scheme of the new IEC of 27 March 2024 covers all of the definitions of AM that were mentioned in the evidence (in particular, both "swish AM" and "thump AM").

This report has applied the same AM adjustment to the measurements presented below.

2.3 Institute of Acoustics Reference Method (IOA RM)

Amplitude Modulation has been defined by the IOA AMWG[2] in their final report as:

"Wind turbine amplitude modulation is defined as periodic fluctuations in the level of audible noise from a wind turbine (or wind turbines), the frequency of the fluctuations being related to the blade passing frequency[3] of the turbine rotor(s)."

This Institute of Acoustics (IoA) document goes on to say AM should be assessed externally:

The assessment procedure and metric are intended to be applied to external measurements of noise experienced at locations at 'residential distances', separation distances between large wind turbines and dwellings in the UK being typically 500 metres or greater. The procedure is based on outdoor measurements in the vicinity of dwellings, primarily because of the practical difficulties associated with making repeatable noise measurements indoors. Reliance on external measurements is consistent with established standards and procedures for assessing environmental noise

The IOA provide a Reference Method for defining AM with this IOA RM involving the following stages:

- Noise is measured in short-term, 100-millisecond LAeq values in 1/3-octave bands. Three frequency ranges or bands are evaluated: 50-200 Hz; 100-400 Hz and 200-800 Hz, and the results which exhibit the highest resulting levels of AM are used
- The fundamental length of input sample to be assessed (the minor time interval) is 10 seconds
- The hybrid reconstruction method is used to determine the AM value for each 10 second value
- The values of AM measured by the metric in each 10-second interval are aggregated over a 10-minute period (the major time interval) to provide a single value which is the AM rating for the 10-minute period.

A further review of the methodology was prepared by WSP/ Parsons Brinckerhoff[4] on behalf of the UK Department of Energy and Climate Change (DECC). This document proposed a penalty scheme, as reflected in Figure 1 below.

2.4 Wind Turbine AM Review

The Phase 2 report[5] as provides a decibel penalty which would be added for the purposes of fixing decibel limits. The AM penalty scheme set out in Figure A.1 of Annex A.3 of the new IEC of 27 March 2024 is the same as the AM penalty scheme stipulated in the Phase 2 report.

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[2] Institute of Acoustics Amplitude Working Group, Final Report 9 August 2016

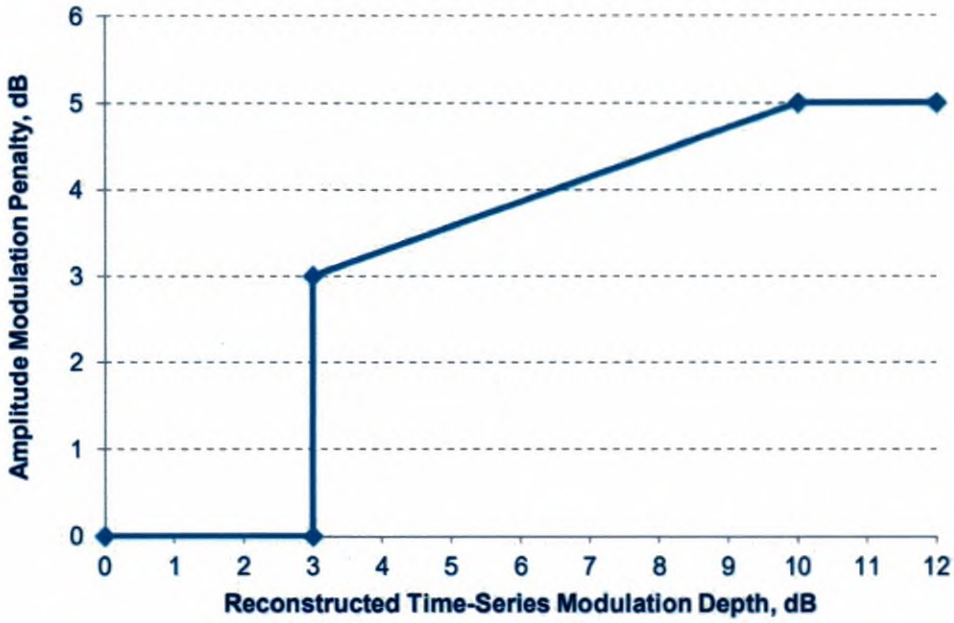
[3] Blade Passing frequency (Hz) = (Rotor RPM) x (No. of blades)/60

[4] Wind Turbine AM Review, Phase 2 Report, WSP/Parsons Brinkerhoff, August 2016, Department of Energy & Climate Change (UK)

[5] Wind Turbine AM Review, Phase 2 Report, Department of Energy & Climate Change, Aug 2016

Figure 1 below shows the AM penalty to be applied to the associated Modulation Depth. It should also be noted that the AM penalty scheme set out in Figure 1 of below is the only AM penalty scheme set out in the new IEC of 27 March 2024 for penalising AM and is equally applicable to all types of AM including both the "swish" and "thump AM".

Figure 1: Proposed Penalty Scheme



The same methodologies and assessment procedures have been used in this report and the penalties applied to the occurrences of AM in the results of below were applied as per Figure 1 above.

2.5 Institute of Acoustics Good Practice Guide – May 2013

The Institute of Acoustics Noise Working Group were tasked with providing a Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise in relation to how noise impacts are considered in relation to wind energy developments. A number of Supplementary Guidance Notes support the Good Practice Guide with SGN 5: 'Post Completion Measurements' providing specific direction on compliance monitoring.

Various aspects of the compliance monitoring were addressed in this document, including:

- Noise Limits in Planning Conditions;
- Measurement of Wind Speed;
- Measurement Locations and Instrumentation;
- Noise Data and Data Processing;
- Outcome of Measurement Exercise.

The requirements of this document were incorporated into the compliance measurement methodology to ensure that the measurement methodology was conducted in line with what is considered good practice.

SGN5 with respect to considering worst case downwind scenarios states, *"Application of the noise conditions often requires consideration of conditions prevalent during the complaints, but it is also standard practice to consider downwind conditions because of propagation effects. Downwind conditions can generally be defined for each location as conditions in which the angle between the wind direction and the direct line from any wind turbine to the measurement location considered is no greater than 45 degrees."*