codling wind park

Environmental Impact Assessment Report

Volume 4

Appendix 24.3 Operational Phase Offshore Wind Farm Turbine Noise


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Table of contents

List of tables

Abbreviations

Abbreviation	Term in Full
BS	British standard
CWP	Codling Wind Park
EIA Report	Environmental Impact Assessment Report
OWF	Offshore wind farm
O&M	Operations and maintenance
WTG	Wind turbine generator

Definitions

Glossary	Meaning
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.
dB (decibel)	The unit normally employed to measure the magnitude of sound. 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.
hertz (Hz)	The unit of sound frequency in cycles per second.
$L_{Aeq,T}$	This 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 (T).The closer the L_{Aeq} value is to either the LAF10 or LAF90 value indicates the relative impact of the intermittent sources and their contribution. The relative spread between the values determines the impact of intermittent sources such as traffic on the background.
L_{AF90}	Refers to those A-weighted noise levels in the lower 90 percentile of the sampling interval; it is the level which is exceeded for 90% of the measurement period. It will therefore exclude the intermittent features of traffic and is used to estimate a background level. Measured using the “Fast” time weighting.
noise	Sound that evokes a feeling of displeasure in the environment in which it is heard, and is therefore unwelcomed by the receiver
Noise Sensitive Location (NSL)	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.
octave band	A frequency interval, the upper limit of which is twice that of the lower limit. For example, the 1,000Hz octave band contains acoustical energy between 707Hz and 1,414Hz. The centre frequencies used for the designation of octave bands are defined in ISO and ANSI standards.
sound power level (L_W)	The sound power level radiated by a source is defined as: $L_p = 10 \times \log_{10}(W/W_o)$ dB. Where W is the acoustic power of the source in Watts (W) and Wo 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: $L_p = 20 \times \log_{10}(P/P_o)$ dB.

Glossary	Meaning
	Where P is the sound pressure and P_o is a reference pressure for propagation of sound in air and has a value of $2x10^{-5}$Pa.
V_{10}	Standarised 10m wind speed

APPENDIX 24.3 OPERATIONAL PHASE OWF TURBINE NOISE

1 Introduction

1. Codling Wind Park Limited (hereafter 'the Applicant') is proposing to develop the Codling Wind Park (CWP) Project, which is located in the Irish sea approximately 13 - 22 km off the east coast of Ireland, at County Wicklow.

2. This appendix forms part of **Chapter 24 Noise and Vibration** of the Environmental Impact Assessment Report (EIAR) for the CWP Project.

3. This appendix presents the following input data related to the O&M phase of the Offshore Wind Farm (OWF) Wind turbine generator (WTG) noise modelling presented in **Chapter 24 Noise and Vibration**.

- O&M modelling input data for CWP OWF Option A WTG at rated power.
- O&M modelling input data for CWP OWF Option B WTG at rated power.
- Extract from Dublin Array OWF cumulative operational noise modelling methodology and inputs.

2 O&M modelling input data for CWP OWF Option A

2.1 Option A WTG coordinates

4. The coordinates for the 163m hub height Option A WTG (75 no.) are summarised in **Table 1** below.

Table 1 Option A WTG coordinates

ID	Easting (ITM Ref.)	Northing (ITM Ref.)	ID	Easting (ITM Ref.)	Northing (ITM Ref.)
A01	744,463	712,343	B03	745,706	709,776
B01	745,627	712,380	C13	747,268	696,793
C06	746,990	705,907	C12	747,229	698,095
C04	746,910	708,511	C10	747,149	700,699
C02	746,830	711,115	C08	747,069	703,303
C01	746,790	712,416	D13	748,436	696,829
G12	751,895	698,240	D12	748,395	698,131
G11	751,854	699,543	D10	748,315	700,735
G10	751,814	700,844	D08	748,235	703,339
G09	751,772	702,147	D06	748,154	705,943
G08	751,731	703,449	D04	748,074	708,547
G07	751,690	704,751	D02	747,993	711,151
G06	751,649	706,053	D01	747,953	712,452

ID	Easting (ITM Ref.)	Northing (ITM Ref.)	ID	Easting (ITM Ref.)	Northing (ITM Ref.)
G05	751,607	707,354	E13	749,602	696,865
G04	751,566	708,657	E12	749,562	698,168
H12	753,062	698,278	E10	749,481	700,772
H11	753,021	699,579	E08	749,400	703,376
H10	752,979	700,882	E06	749,319	705,979
H09	752,938	702,183	E04	749,238	708,583
H08	752,896	703,485	E03	749,198	709,886
H07	752,855	704,787	E02	749,157	711,187
H06	752,813	706,089	F13	750,769	696,903
H05	752,772	707,392	F12	750,729	698,204
H04	752,731	708,693	F11	750,688	699,507
A13	744,935	696,720	F10	750,647	700,808
A12	744,895	698,021	F09	750,606	702,110
A11	744,856	699,324	F08	750,565	703,412
A10	744,816	700,625	F06	750,484	706,016
A05	744,621	707,136	F05	750,443	707,318
A04	744,581	708,437	F04	750,402	708,621
B13	746,101	696,756	F03	750,361	709,922
B12	746,062	698,058	G03	751,415	709,894
B11	746,022	699,360	B02	745,592	711,034
B10	745,983	700,662	G13	751,852	696,950
B07	745,864	704,568	B09	745,975	701,959
B06	745,824	705,869	B08	746,065	703,297
B05	745,785	707,172	A06	744,719	705,884
B04	745,745	708,473			

2.2 Option A WTG inputs

5. CWP provided the sound power level data as 115 dB (A) at rated power 8 m/s. In accordance with the IOA GPG, sound power levels referred to wind speeds at standardised 10 m height (V_{10}). The WTG sound power level was provided by CWP in terms of the L_{Aeq} parameter.

6. **Table 2** presents details of the octave band sound power level data provided by CWP for the WTG that has been used for the operational WTG noise prediction modelling assessment in Option A.

Table 2 Option A OWF Octave Band Sound Power Spectrum at Rated Power

Rated Power Wind Speed	Octave Band (Hz) Sound Power Levels (dB re 10-12W)								dB (A)
	63	125	250	500	1k	2k	4k	8k	
8 m/s	94.3	99.9	105.9	110.1	110.6	106.3	96.7	75.0	115.0

7. As per best practice guidance contained within the IOA GPG, an allowance for uncertainty in the measurement of WTG source levels of +2 dB is applied in modelling to all WTG sound power levels in **Table 2**.

8. The operational criteria are couched in terms of a L_{A90} criterion. Best practice guidance in the IOA GPG states that "L_{A90} levels should be determined from calculated L_{Aeq} levels by subtraction of 2 dB". A 2 dB reduction has therefore been applied in the noise model calculations. All predicted noise levels presented below are presented in terms of L_{A90} parameter, i.e., this reduction of 2 dB is applied in the noise prediction modelling.

9. The calculation of operational noise levels at NSLs has been carried out for a reference wind speed V_{10} of 8 m/s in accordance with the Danish methodology (BEK no. 135).

10. Air absorption calculated at 10°C and 80% relative humidity (in accordance with the Danish methodology - BEK no. 135).

2.3 Location of closest Noise Sensitive Location (NSL)

11. In Option A the closest onshore NSL is WTG NSL01, which is located at approximately 13 km distance (Easting 733,317, Northing 690,867 ITM Ref.) to the closest southwestern WTG (A13 in WTG Option A) (Easting 744,935, Northing 696,720 ITM Ref.).

3 O&M modelling input data for CWP OWF Option B

3.1 Option B WTG coordinates

12. The coordinates for the 176m hub height Option B WTG (60 no.) are summarised in **Table 3** below.

Table 3 Option B WTG coordinates

ID	Easting (ITM Ref.)	Northing (ITM Ref.)	ID	Easting (ITM Ref.)	Northing (ITM Ref.)
A12	744,921	696,725	F07	751,497	704,023
B12	746,259	696,764	G07	752,861	704,065
C12	747,622	696,804	B07	746,215	703,794
D12	748,985	696,846	F06	751,454	705,443
E12	750,348	696,887	G06	752,818	705,484
F12	751,710	696,928	A05	744,597	706,657

ID	Easting (ITM Ref.)	Northing (ITM Ref.)	ID	Easting (ITM Ref.)	Northing (ITM Ref.)
A11	744,879	698,144	B05	745,960	706,698
B11	746,216	698,184	C05	747,322	706,739
C11	747,579	698,224	D05	748,686	706,780
D11	748,942	698,265	E05	750,049	706,821
E11	750,305	698,306	F05	751,412	706,863
F11	751,667	698,347	G05	752,775	706,904
G11	753,032	698,388	A04	744,554	708,076
A10	744,836	699,563	B04	745,918	708,118
B10	746,174	699,602	F04	751,369	708,281
E10	750,263	699,725	G04	752,731	708,323
F10	751,625	699,766	A03	744,750	709,447
G10	752,988	699,808	C03	747,238	709,578
A09	744,793	700,982	D03	748,601	709,619
B09	746,131	701,021	E03	749,963	709,660
C09	747,494	701,062	F03	751,327	709,701
D09	748,856	701,104	B02	745,832	710,956
E09	750,220	701,145	D02	748,558	711,038
F09	751,583	701,185	E02	749,920	711,079
G09	752,946	701,226	A01	744,426	712,334
B08	746,137	702,441	B01	745,789	712,375
G08	752,903	702,646	C01	747,152	712,416
C07	747,413	703,815	D01	748,233	712,451
D07	748,771	703,942	B06	746,003	705,278
E07	750,135	703,983	B03	745,874	709,536

3.2 Option B WTG inputs

13. CWP provided the sound power level data as 121 dB (A) at rated power 8 m/s. In accordance with the IOA GPG, sound power levels referred to wind speeds at standardised 10 m height (V_{10}). The WTG sound power level was provided by CWP in terms of the L_{Aeq} parameter.

14. **Table 4** presents details of the octave band sound power level data provided by CWP for the WTG that has been used for the operational WTG noise prediction modelling assessment in Option B.

Table 4 Option A OWF Octave Band Sound Power Spectrum at Rated Power

Rated Power Wind Speed	Octave Band (Hz) Sound Power Levels (dB re 10-12W)								dB (A)
	63	125	250	500	1k	2k	4k	8k	
8 m/s	100.2	105.8	111.8	116.0	116.5	112.2	102.6	80.9	120.9

15. There was no change in Option B to the uncertainty and best practice outlined in detail in Option A earlier i.e. in line with IOA GPG and the Danish methodology (BEK no. 135).

3.3 Location of closest NSL

16. The closest onshore NSL is WTG NSL01, which is located at approximately 13 km distance (Easting 733,317, Northing 690,867 ITM Ref.) to the closest southwestern WTG (A12 in WTG Option B) (Easting 744,921, Northing 696,725 ITM Ref.).

4 CWP and Dublin Array OWF cumulative operational noise assessment

17. The acoustic consultants for the Dublin Array OWF (Bow Acoustics) modelled the cumulative operational noise from CWF (Option B) and DA (Option A).

18. The Danish methodology (BEK no. 135) was applied along with the IOA GPG recommendations regarding the L_{A90} criterion.

19. A full copy of the DA cumulative operational noise note supplied to CWP is presented at the end of the appendix for reference.

5 References

20. Danish Ministry of the Environment, Executive Order on Noise from Wind Turbines: BEK no.135 of 7 February 2019.

21. Institute of Acoustics (IoA) document A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (IOA, 2013).

6 DA OWF cumulative operational noise note

Dublin Array Offshore Wind Farm
Cumulative Operational Noise

BOW ACOUSTICS

1 Introduction

1.1.1 This note provides an overview of the calculation methodology used to determine cumulative operational noise from Dublin Array Offshore Wind Farm (DA OWF) and Codling Wind Park (CWP).

1.1.2 The calculation of operational noise propagation of DA OWF and CWP was in accordance with BEK No. 135. This method provides the current best practice for the calculation of wind turbine noise over a large body of water. It is recognised in the UK Institute of Acoustics document '*A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*' (IOA GPG) that conventional prediction methods that are suitable for onshore wind turbine noise, such as ISO 9613-2 are not appropriate for offshore wind turbine noise as they would result in an underprediction. The method employed by BEK accounts for cylindrical spreading of sound and multiple reflections that occur over large distances and over reflective surfaces such as water.

2 Methodology

2.1.1 The calculation was performed in octave bands from 63 Hz to 8 kHz following the method provided in BEK No. 135, reproduced in Equation 1 below.

Equation 1 - calculation of sound pressure level

$$L_{pA} = L_{WA,ref} - 10 \times \log(l^2 + h^2) - 11 + \Delta L_g - \Delta L_a + \Delta L_m$$

Where:

L_{pA}	is the sound pressure level, in dB LAeq, at the calculation point
$L_{WA,ref}$	is the sound power level of the wind turbine at the reference wind speed
l	is the distance from the base of the wind turbine to the calculation point
h	is the hub height of turbine above MHWS
11	is a correction of distance equal to 10 x log(4π)
ΔL_g	is a correction for terrain.
ΔL_a	is the attenuation in sound due to air absorption
ΔL_m	is a correction for multiple reflections

2.1.2 For the terrain correction term, ΔL_g, 3 dB has been used when calculating the sound pressure level from offshore wind turbines at a building close to the coast. For a building that, when viewed in the direction of the wind turbines, is more than 200 m from the coast, 1.5 dB has been used. For buildings between 0 and 200 m from the coast, a linear interpolation has been applied.

2.1.3 Equation 1 was used to calculate the operational sound pressure level at the receiver location from each wind turbine within the arrays. The calculation of ΔL_m is carried out by determining the threshold distance for each individual wind turbine based on its downwind component for a wind vector from the nearest turbine to the calculation point blowing directly at the calculation point. Therefore, the calculation assumes downwind propagation for the closest turbine and corrects for the downwind component for all other turbines. The correction for downwind component is given by Equation 2.

Equation 2 - calculation of downwind component

$$V_{ref,k,i} = V_{ref} \times \cos\theta_{in}$$

Where:

$V_{ref,k,i}$	is the downwind component of the wind speed at a reference height of 10 m
V_{ref}	is the wind speed at a reference height of 10 m
ϑ_{in}	is the angle between the direction of the calculation point to the nearest turbine and the direction form the calculation point to the i^{th} wind turbine

2.1.4 The calculation for operational noise has been carried out for a reference wind speed V_{10} of 8 m/s in accordance with BEK 135. Where the standardised 10 m wind speed is calculated from hub height using a logarithmic profile with a reference surface roughness of 0.05 m in accordance with IEC 61400-11 and summarised in Equation 3.

Equation 3 - wind shear to standardised 10 m

$$v_{10} = v_{hh} \frac{\ln\left(\frac{10m}{z_{0,ref}}\right)}{\ln\left(\frac{H_{hh}}{z_{0,ref}}\right)}$$

Where:

V_{10}	is the standardised 10 m wind speed
V_{hh}	is the wind speed at hub height
$Z_{0,ref}$	is the reference surface roughness of 0.05 m
H_{hh}	is the height of the hub in m

2.1.5 The following assumptions have been made for the calculation of operational wind turbine noise:

- 10° C and 80% relative humidity (in accordance with BEK-135);
- Source height as per the hub height in metres above MHWS;
  - DA OWF hub height of 146 m;
  - CWP hub height of 176 m;
- DA OWF noisiest layout, Option A: 50 x 236m rotor diameter turbines.
- CWP noisiest layout: 60 x 276m rotor diameter turbines.
- Wind speed reference of V_{10} 8 m/s;
- Downwind propagation for the closest turbine, as described in Paragraph 2.1.3; and
- No correction for exposure time – assumes constant noise through assessment period.

2.1.6 All predicted wind turbine noise levels at NSRs presented in this chapter use the L_{A90} noise indicator in accordance with the recommendations of the ETSU-R-97 report, which have been obtained by subtracting 2 dB(A) from the calculated L_{Aeq} noise levels as a result of the above calculation method and sound power data. This is in accordance with SB20 of the IOA GPG.

3 Wind Turbine Coordinates

3.1 Dublin Array

3.1.1 The coordinates for the DA OWF layout Option A (correct at the time of writing) are summarised in Table 1.

Table 1: Dublin Array Offshore Wind Farm turbine coordinates

ID	X, ITM	Y, ITM	ID	X, ITM	Y, ITM
T1	739879	728138	T26	739375	713224
T2	739814	730587	T27	738355	716899
T3	738427	728519	T28	738302	715831
T4	739909	727125	T29	738117	722012
T5	740007	723808	T30	738509	723136
T6	738170	729524	T31	736966	723526
T7	739140	729858	T32	739202	715289
T8	738968	726549	T33	738223	718809
T9	738689	727478	T34	740318	720826
T10	739852	729184	T35	740213	719781
T11	739665	724763	T36	741382	715144
T12	739299	725636	T37	741319	717249
T13	736843	727762	T38	741098	720209
T14	739406	714267	T39	741421	713792
T15	738327	714750	T40	740397	716751
T16	738124	724041	T41	741350	716163
T17	736952	724699	T42	741243	718239
T18	738151	720790	T43	741192	721256
T19	736870	726607	T44	740592	713291
T10	738979	721470	T45	740405	717745
T21	738540	717890	T46	740810	722265
T22	737155	725686	T47	740486	714703
T23	736990	722449	T48	740170	718662
T24	738395	719873	T49	740294	715752
T25	738355	713725	T50	741261	719230

3.2 Codling Wind Park

3.2.1 The turbine coordinates for CWP (correct at the time of writing) are summarised in Table 2.

Table 2: Codling Wind Park turbine coordinates

ID	X, ITM	Y, ITM	ID	X, ITM	Y, ITM
A12	744921	696725	F07	751497	704023
B12	746259	696764	G07	752861	704065
C12	747622	696804	B07	746215	703794
D12	748985	696846	F06	751454	705443
E12	750348	696887	G06	752818	705484
F12	751710	696928	A05	744597	706657
A11	744879	698144	B05	745960	706698
B11	746216	698184	C05	747322	706739
C11	747579	698224	D05	748686	706780
D11	748942	698265	E05	750049	706821
E11	750305	698306	F05	751412	706863
F11	751667	698347	G05	752775	706904
G11	753032	698388	A04	744554	708076
A10	744836	699563	B04	745918	708118
B10	746174	699602	F04	751369	708281
E10	750263	699725	G04	752731	708323
F10	751625	699766	A03	744750	709447
G10	752988	699808	C03	747238	709578
A09	744793	700982	D03	748601	709619
B09	746131	701021	E03	749963	709660
C09	747494	701062	F03	751327	709701
D09	748856	701104	B02	745832	710956
E09	750220	701145	D02	748558	711038
F09	751583	701185	E02	749920	711079
G09	752946	701226	A01	744426	712334
B08	746137	702441	B01	745789	712375
G08	752903	702646	C01	747152	712416
C07	747413	703815	D01	748233	712451
D07	748771	703942	B06	746003	705278
E07	750135	703983	B03	745874	709536