



Acoustic Assessment for Rotor Diameter Planning Variation at Upper Ogmore Wind Farm

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CONTENTS

1. INTRODUCTION	2
2. PLANNING CONDITIONS	2
3. PREDICTIONS	4
4. ASSESSMENT	6
5. MITIGATION/CURTAILMENT	8
6. CONCLUSIONS	11
7. REFERENCES	12
APPENDIX A - DECISION NOTICE & PLANNING CONDITIONS	13
APPENDIX B - ORIGINAL ACOUSTIC ASSESSMENT	14

1. INTRODUCTION

An acoustic assessment of Upper Ogmores Wind Farm has been performed to determine whether the project is predicted to comply with planning conditions relating to noise, as specified within the planning consent documentation issued by Welsh Ministers on behalf of the Welsh Government. The report is intended to support a planning application to vary the rotor diameter of the turbine to be installed at the site.

The assessment methodology follows applicable guidance on operational noise from wind turbines in the UK i.e. the Institute of Acoustics - A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise (IOA GPG).

In instances where the predicted noise levels are above the limiting requirements of the planning conditions, for the scenario where the turbines are assumed to be operating unrestricted, mitigation measures, in the form of curtailment of the candidate turbine to be installed at the site, have been determined and reported here such that the limits are predicted to be met.

2. PLANNING CONDITIONS

The planning condition noise limits for the Upper Ogmores Wind Farm at dwellings neighbouring the development are specified within Tables A1 to A6 and B1 to B6 of the planning consent documentation for the site (Ref. qA1452991) [1] as provided at Appendix A of this report. The limiting values are referenced to standardised 10 m height wind speeds.

The noise limits are also specified in relation to wind direction for daytime and night-time periods respectively and are applied with the intention of limiting noise associated with the operation of the development when considered in the context of other operational and/or planned wind farm sites in the vicinity of Upper Ogmores. Effectively, the limits are set to help to ensure that overall cumulative operational noise levels do not exceed overall cumulative noise limits specified as part of planning guidance, whereas specific planning condition limits can only apply to the certain development for which the conditions are applicable.

The resultant limits are relatively low in many instances, often less than 30 dB L_{A90} for daytime periods. Such levels may be particularly difficult to measure in practice as the influence of other noise sources such as traffic, wind induced noise, birdsong, including other general environmental noise sources and operational noise from other wind farms in the area can easily corrupt the measurements. This could make any specific determination of compliance or otherwise with the planning condition limits via typical measurement practices difficult to be asserted with any certainty.

Conditions 29 to 38 and the associated Guidance Notes attached to the planning permission documentation relate to the procedures involved with the assessment and the measurement of noise associated with the operation of the development should an allegation of noise disturbance be received. The conditions are summarised as follows:

- Condition 29 refers to the noise limits applicable at dwellings neighbouring the site, adding that any dwellings not listed within the tables attached to the consent can be assumed to have the same limits as the closest dwelling for which values are available, unless otherwise agreed with the relevant Local Planning Authority (LPA).
- Condition 30 specifies that an independent consultant will be required to assess, via measurement, the operational noise levels associated with the operation of the development in the event of an alleged disturbance and/or if a complaint is received in relation to the operation of the Upper Ogmores site or the neighbouring Llynfi Afan wind farm. However, it would seem appropriate for any potential measurement campaign to focus on the site for which any potential complaints or alleged disturbance is directed as the operators of Upper Ogmores wind farm do not have any direct influence or control over the operation of other neighbouring wind farm development.

- Condition 31 states that the findings of the independent consultants' assessment referred to above and any associated data should be provided to the LPA in a form that allows verification of the results.
- Condition 32 requires that, in the event of an identified breach of the planning noise limits, a scheme for remedial mitigation/curtailment of the turbines to be submitted to and approved by the LPA.
- Condition 33, similarly to part of Condition 29, states that where a complainants' dwelling is not listed within the relevant tables attached to the consent, the noise limits applied to the dwelling should be agreed in writing with the LPA.
- Condition 34 requires that a protocol for the measurement of noise resulting from the operation of the wind farm(s) to be submitted and approved in writing prior any measurement and assessment works being undertaken. The condition also requires the meteorological and operational conditions under which the disturbance is alleged and the character of the noise causing the disturbance (i.e. in respect of any potential tonal noise) to be identified.
- Condition 35 requires that wind speed, wind direction and power generation information is supplied to the LPA to enable a check of any assessment works in respect of whether the site complies with the noise limits. The condition also requires that this information is retained by the operator for a nominal period.
- Condition 36, similarly to Condition 30, requires an independent consultant, approved in writing by the LPA, to assess the noise levels associated with the operation of the wind farm in accordance with the planning conditions, guidance notes and a specified, pre-approved, assessment protocol.
- Condition 37 states that, in the instance where the proposed turbine model for installation at the site has higher sound power levels or that the noise associated with the operation of the turbines may be more tonal than that assumed within the Environmental Statement (ES) supporting the planning application for the site, a revised noise assessment shall be submitted to the LPA. The report should detail show the operational noise levels associated with the installation of the alternative candidate turbine and any associated mitigation/curtailment required to comply with the planning condition noise limits, as detailed within this report.
- Conditions 38 states that the site operator will designate someone to act as point of contact between the LPA and the site with respect to the process and discharge, where possible, of conditions 30 through 35 described above, in relation to operational noise, and in relation to any noise complaints associated with the construction and decommissioning of the development.
- The Guidance Notes attached to the planning consent document sets out the noise limits, includes an overview of the rationale for the setting of these values, and provides the general procedure for noise compliance measurements to be undertaken in the event of an alleged disturbance, including for any potential penalties should tonal noise (i.e. a hum, whine or whistle) be present at a potential complainants dwelling.

Further to the above, the acoustic assessment that supported the original planning application for the development is provided at Appendix B. A direct comparison between the assessment provided here and the original works is not possible as the basis of assessment has changed, via the consenting process, in terms of the rationale for setting specific noise limits for Upper Ogmere operating in isolation (as discussed within the planning consent documentation for the site). However, both assessments result in overall cumulative operational noise levels that would be expected to meet the overall requirements of ETSU-R-97 and are similar in that sense.

3. PREDICTIONS

The propagation model described within ISO 9613-2 [2] has been used to undertake predictions of the expected noise levels resulting from the operation of the development. The model accounts for geometric spreading, atmospheric absorption, ground and barrier effects. The specific assumptions used and interpretation of the propagation prediction methodology, as detailed in an Acoustics Bulletin article, authored by a group of independent acousticians experienced in wind farm noise issues in February 2009 [3], as reaffirmed in the IOA GPG [4], has been used.

The recommended assumptions include the use of atmospheric absorption values corresponding to temperature of 10 °C, a relative humidity of 70 % as defined within ISO9613-1 [5], the application of a +3 dB correction should propagation across a valley occur and the limitation of barrier attenuation to -2 dB where there is no direct line-of-sight between a source and receiver due to the intervening topography. The resultant predicted noise levels are considered conservative in nature as an appropriate level of uncertainty has been applied to the candidate turbine source noise levels and the effects of trees and other non-terrain related shielding have not been considered.

A ground absorption coefficient of $G=0.5$ and a receiver height of 4 m is assumed. Furthermore, the resultant predicted dB L_{Aeq} noise levels have been converted to dB L_{A90} values by subtracting 2 dB to allow for comparison with the limits. All inline with the recommendations of the IOA GPG.

Additionally, rather than making a conservative assumption that properties are always downwind of the wind farm, a more detailed assessment, which incorporates the effects of wind direction has been undertaken. This accounts for the fact that noise levels at a property will be less when the property is crosswind or upwind of the development. The directional attenuation factors applied, as shown at Table 1, are consistent with the recommendations of the IOA GPG; with reductions in noise of around 2 dB when a receiver is crosswind, and up to 10 dB when a receiver is upwind of a particular turbine. The IOA GPG also states that upwind reductions in noise level will only come into play gradually at distances of between 5 and 10 tip heights. As a result, the attenuation factors applied have been adjusted by the distance between the source and receiver accordingly.

Table 1 - Directional Attenuation

Directional Offset from Directly Downwind, °	0	30	60	90	120	150	180	210	240	270	300	330
Directional Attenuation Factor, dB	0	0	0	-2	-6.7	-9.3	-10	-9.3	-6.7	-2	0	0

The dwelling locations considered as part of the assessment are listed at Table 2 below. These correspond to that specified as part of the planning conditions for the development and RES house layout reference DWALuog005.

Table 2 - House Locations

House ID	OSGB Co-ordinates		House ID	OSGB Co-ordinates	
	X / m	Y / m		X / m	Y / m
H1	290444	193183	H9	289368	196146
H2	294341	195716	H10	287709	192104
H3	293130	193296	H11	290048	193644
H4	289909	193514	H12	287062	195082
H5	293425	193458	H13	289431	196124
H6	289339	196040	H14	290404	193174
H7	290069	193653	H15	293626	193025

House ID	OSGB Co-ordinates		House ID	OSGB Co-ordinates	
	X / m	Y / m		X / m	Y / m
H8	290722	193207			

The consented turbine locations considered as part of the assessment provided herein are shown at Table 3. These correspond to RES turbine layout reference PWALuog075.

Table 3 - Turbine Locations

Turbine ID	OSGB Co-ordinates		Turbine ID	OSGB Co-ordinates	
	X / m	Y / m		X / m	Y / m
T1	290447	194753	T5	292241	194567
T2	290975	194891	T6	292513	194333
T3	291597	194671	T7	291182	194634
T4	292020	194782			

The predictions assume the installation of Nordex N117 3.6 MW turbines with a hub height of 91.5 m at the consented locations shown at Table 3. The corresponding source noise levels, as obtained from documentation supplied by the turbine manufacturer [6], assuming the use of serrated trailing edge (STE) blade modifications and with a +2 dB allowance for uncertainty included, are shown at Table 4. This approach concurs with the approach recommended within the IOA GPG and is considered to provide a reasonably conservative basis of assessment. The source noise information has been supplied with direct reference to specific standardised 10 m height wind speeds which allows for comparison with the planning condition noise limits. Furthermore, it is possible to operate this model of turbine in a variety of operational modes which may be implemented for numerous parameters not limited to wind speed, direction and time. The source noise levels for a variety of the noise modes which could be implemented at the wind farm, including for the applied uncertainty discussed earlier, are also shown.

Table 4 - Nordex N117 Sound Power Levels, dB L_{WA}

Turbine Mode	Standardised 10 m Height Wind Speed, m.s ⁻¹									
	3	4	5	6	7	8	9	10	11	12
Mode 0 (M0)	94.5	96.5	102.0	105.0	105.5	105.5	105.5	105.5	105.5	105.5
Mode 1 (M1)	94.5	96.5	102.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
Mode 2 (M2)	94.5	96.5	102.0	104.5	104.5	104.5	104.5	104.5	104.5	104.5
Mode 3 (M3)	94.5	96.5	102.0	104.0	104.0	104.0	104.0	104.0	104.0	104.0
Mode 4 (M4)	94.5	96.5	102.0	103.5	103.5	103.5	103.5	103.5	103.5	103.5
Mode 5 (M5)	94.5	96.5	101.0	101.0	101.0	101.0	101.0	101.0	101.0	101.0
Mode 6 (M6)	94.5	96.5	100.5	100.5	100.5	100.5	100.5	100.5	100.5	100.5
Mode 7 (M7)	94.5	96.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mode 8 (M8)	94.5	96.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5
Mode 9 (M9)	94.5	96.5	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0
Mode 10 (M10)	94.5	96.5	98.5	98.5	98.5	98.5	98.5	98.5	98.5	98.5
Mode 11 (M11)	94.5	96.5	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0
Mode 12 (M12)	94.5	96.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5

The octave band noise levels, as also supplied by the turbine manufacturer [7], corresponding to the maximum noise output of the N117 3.6 MW turbine considered here, operating unrestricted and incorporating the uncertainty described earlier, are shown at Table 5. These octave band noise levels have been adjusted to represent the overall noise levels specified for other/lower wind speeds and for

other operational noise modes by subtracting the relative difference between the maximum noise level for unrestricted operation and the level corresponding wind speed/mode of interest from each overall octave band level.

Table 5 - Octave Band Sound Power Levels, dB L_{WA}

Turbine	Overall, dB L _{WA}	Centre of Octave Band, Hz							
		63	125	250	500	1k	2k	4k	8k
N117	105.5	86.2	92.4	95.3	95.8	98.6	100.0	99.0	89.7

The candidate turbine is assumed not to have any tonal noise output that would attract a penalty at neighbouring residences under the scheme specified by the Guidance Notes attached to the planning consent for the site. A warranty or guarantee will be obtained from the manufacturer which limits the level of tonal noise associated with the operation of the individual turbines (or the site as a whole), should the candidate model of turbine be installed. This will help to ensure tonal noise would not require a penalty under the requirements of the Guidance Notes to the planning conditions and provide appropriate recourse with the turbine manufacturer should tonal noise be present.

4. ASSESSMENT

Table 6 shows the resultant maximum predicted turbine noise levels for any given wind direction using the assumptions detailed at Section 3 above.

Table 6 - Maximum Predicted Turbine Noise Levels, dB L_{A90}

House ID	Standardised 10 m Height Wind Speed, m.s ⁻¹									
	3	4	5	6	7	8	9	10	11	12
H1	17.6	19.6	25.1	28.1	28.6	28.6	28.6	28.6	28.6	28.6
H2	12.5	14.6	20.1	23.0	23.5	23.5	23.5	23.5	23.5	23.5
H3	18.2	20.2	25.7	28.7	29.2	29.2	29.2	29.2	29.2	29.2
H4	20.0	22.0	27.5	30.5	31.0	31.0	31.0	31.0	31.0	31.0
H5	18.2	20.2	25.7	28.7	29.2	29.2	29.2	29.2	29.2	29.2
H6	13.7	15.7	21.2	24.2	24.7	24.7	24.7	24.7	24.7	24.7
H7	21.4	23.4	28.9	31.9	32.4	32.4	32.4	32.4	32.4	32.4
H8	17.1	19.1	24.6	27.6	28.1	28.1	28.1	28.1	28.1	28.1
H9	15.0	17.0	22.5	25.5	26.0	26.0	26.0	26.0	26.0	26.0
H10	8.9	10.9	16.4	19.4	19.9	19.9	19.9	19.9	19.9	19.9
H11	21.2	23.3	28.8	31.7	32.2	32.2	32.2	32.2	32.2	32.2
H12	6.5	8.5	14.0	17.0	17.5	17.5	17.5	17.5	17.5	17.5
H13	15.3	17.3	22.8	25.8	26.3	26.3	26.3	26.3	26.3	26.3
H14	18.3	20.3	25.8	28.8	29.3	29.3	29.3	29.3	29.3	29.3
H15	18.1	20.1	25.6	28.6	29.1	29.1	29.1	29.1	29.1	29.1

Tables 7 & 8 show the minimum margin of predicted compliance with the planning condition noise limits for any given wind direction and for the daytime and night-time time periods respectively. A positive number indicates that the predicted noise levels are above the relevant noise limit for a particular wind direction and/or range of wind directions.

Table 7 - Minimum Margin of Compliance - Daytime, dB

House ID	Standardised 10 m Height Wind Speed, m.s ⁻¹									
	3	4	5	6	7	8	9	10	11	12
H1	-9.9	-7.9	-4.5	-2.6	1.1	0.7	-5.6	-7.1	-7.1	-7.1
H2	-15.0	-12.9	-7.4	-5.4	-6.9	-7.1	-7.1	-7.1	-7.1	-7.1
H3	-9.3	-7.3	-3.9	-4.4	-5.5	-5.5	-5.5	-5.5	-5.5	-5.5
H4	-7.5	-6.3	-3.4	2.9	2.4	1.9	1.1	0.8	0.8	0.8
H5	-9.3	-7.3	-4.3	-4.5	-6.0	-6.3	-6.3	-6.3	-6.3	-6.3
H6	-13.8	-11.8	-6.3	-3.3	-2.8	-2.8	-3.9	-5.1	-5.1	-5.1
H7	-6.1	-5.4	-1.3	4.4	3.7	3.2	2.6	2.4	2.4	2.4
H8	-10.4	-8.4	-4.4	-3.8	0.6	0.2	-7.0	-7.0	-7.0	-7.0
H9	-12.5	-10.5	-5.0	-2.0	-1.5	-1.5	-2.7	-3.8	-3.8	-3.8
H10	-18.6	-16.6	-11.1	-8.1	-7.6	-7.6	-7.6	-7.6	-7.6	-7.6
H11	-6.3	-5.6	-1.5	4.2	3.5	3.0	2.4	2.2	2.2	2.2
H12	-21.0	-19.0	-13.5	-10.5	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
H13	-12.2	-10.2	-4.7	-1.7	-1.2	-1.2	-2.4	-3.5	-3.5	-3.5
H14	-9.2	-7.2	-3.6	-1.6	1.8	1.4	-4.6	-5.7	-5.7	-5.7
H15	-9.4	-7.4	-4.4	-5.3	-6.8	-7.1	-7.1	-7.1	-7.1	-7.1

Table 8 - Minimum Margin of Compliance - Night-time, dB

House ID	Standardised 10 m Height Wind Speed, m.s ⁻¹									
	3	4	5	6	7	8	9	10	11	12
H1	-15.4	-13.4	-7.9	-5.4	-6.9	-7.2	-7.2	-7.2	-7.2	-7.2
H2	-20.5	-18.4	-12.9	-10.0	-9.5	-9.5	-9.5	-9.5	-9.5	-9.5
H3	-14.8	-12.8	-7.3	-5.2	-6.3	-6.6	-6.6	-6.6	-6.6	-6.6
H4	-13.0	-11.0	-5.5	-5.6	-7.1	-7.4	-7.4	-7.4	-7.4	-7.4
H5	-14.8	-12.8	-7.3	-5.2	-6.7	-7.0	-7.0	-7.0	-7.0	-7.0
H6	-19.3	-17.3	-11.8	-8.8	-8.3	-8.3	-8.3	-8.3	-8.3	-8.3
H7	-11.6	-9.6	-4.1	-4.9	-5.7	-6.1	-6.1	-6.1	-6.1	-6.1
H8	-15.9	-13.9	-8.4	-5.4	-6.7	-7.0	-7.0	-7.0	-7.0	-7.0
H9	-18.0	-16.0	-10.5	-7.5	-7.0	-7.0	-7.0	-7.0	-7.0	-7.0
H10	-24.1	-22.1	-16.6	-13.6	-13.1	-13.1	-13.1	-13.1	-13.1	-13.1
H11	-11.8	-9.7	-4.2	-4.8	-5.7	-6.1	-6.1	-6.1	-6.1	-6.1
H12	-26.5	-24.5	-19.0	-16.0	-15.5	-15.5	-15.5	-15.5	-15.5	-15.5
H13	-17.7	-15.7	-10.2	-7.2	-6.7	-7.1	-7.1	-7.1	-7.1	-7.1
H14	-14.7	-12.7	-7.2	-4.5	-6.1	-6.4	-6.4	-6.4	-6.4	-6.4
H15	-14.9	-12.9	-7.4	-5.3	-6.8	-7.1	-7.1	-7.1	-7.1	-7.1

The results show that the predicted turbine noise levels, when accounting for the effects of wind direction (see Section 3), are above the daytime planning condition noise limits by up to 4.4 dB for a standardised 10 m height wind speeds above 6 m.s⁻¹ and one or more wind direction sectors (see Table 7). This occurs at dwellings located to the southwest of the development (i.e. dwellings in the vicinity of H1, H4, H7, H8, H11 and H14) for northerly and easterly wind directions whereas the prevailing

wind direction is south westerly, as is typical for the UK in general. The night-time noise limits are complied with in all instances (see Table 8).

As a result of the predicted noise levels being above the planning condition limits at certain residences for daytime periods and specific wind speeds and directions, one potential curtailment strategy is shown at Section 5 below. This demonstrates that operational noise levels can meet the limiting requirements of the planning conditions provided that the turbines to be installed at the site are operated in a certain way.

5. MITIGATION/CURTAILMENT

A mitigation/curtailment strategy has been determined, which accounts for the wind regime at the site, the planning condition noise limits, the various power curves and overall noise levels associated with the operational modes detailed at Table 4, with a view to minimising the potential losses in generating capacity resulting from the potential implementation of the strategy.

The proprietary in-house RES methodology for determining the curtailment scenario incorporates machine learning techniques to provide an expected best outcome in terms of potential overall generating capacity whilst maintaining compliance with the limiting requirements in relation to operational noise. An initial derived curtailment strategy is shown at Table 9.

Where no particular mode of operation is indicated or a turbine is not referenced, the turbines are assumed to be operating unrestricted, i.e. no curtailment is required to meet the planning condition noise limits for the corresponding wind speeds and directions.

Table 9 - Potential Daytime Curtailment Strategy

Wind Direction (°)	Standardised 10 m Height Wind Speed, m.s ⁻¹									
	3	4	5	6	7	8	9	10	11	12
Turbine 1										
0	-	-	-	M12	M8	M7	M5	M8	M8	M8
30	-	-	-	M12	M8	M7	M5	M8	M8	M8
60	-	-	-	M4	M5	-	-	M5	M5	M5
90	-	-	-	M4	M5	-	-	M5	M5	M5
120	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-
180	-	-	-	-	-	-	-	-	-	-
210	-	-	-	-	-	-	-	-	-	-
240	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-
300	-	-	-	M7	M5	M5	M2	M2	M2	M2
330	-	-	-	M8	M7	M8	M7	M5	M5	M5
Turbine 2										
0	-	-	-	M5	M4	-	-	-	-	-
30	-	-	-	M5	M2	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-
180	-	-	-	-	-	-	-	-	-	-

Wind Direction (°)	Standardised 10 m Height Wind Speed, m.s ⁻¹									
	3	4	5	6	7	8	9	10	11	12
210	-	-	-	-	-	-	-	-	-	-
240	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-
300	-	-	-	M2	-	-	-	-	-	-
330	-	-	-	M6	M2	M1	-	-	-	-
Turbine 3										
0	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	M2	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-
180	-	-	-	-	-	-	-	-	-	-
210	-	-	-	-	-	-	-	-	-	-
240	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-
300	-	-	-	-	-	-	-	-	-	-
330	-	-	-	-	-	-	-	-	-	-
Turbine 4										
0	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	M2	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-
180	-	-	-	-	-	-	-	-	-	-
210	-	-	-	-	-	-	-	-	-	-
240	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-
300	-	-	-	-	-	-	-	-	-	-
330	-	-	-	-	-	-	-	-	-	-
Turbine 7										
0	-	-	-	M8	M7	M7	M5	M4	M4	M4
30	-	-	-	M8	M7	M7	M5	M4	M4	M4
60	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-
150	-	-	-	-	-	-	-	-	-	-
180	-	-	-	-	-	-	-	-	-	-
210	-	-	-	-	-	-	-	-	-	-

Wind Direction (°)	Standardised 10 m Height Wind Speed, m.s ⁻¹									
	3	4	5	6	7	8	9	10	11	12
240	-	-	-	-	-	-	-	-	-	-
270	-	-	-	-	-	-	-	-	-	-
300	-	-	-	-	-	-	-	-	-	-
330	-	-	-	M7	M6	M4	-	-	-	-

There are many other approaches or combinations of applied noise modes which would allow the predicted noise levels associated with the site to meet the requirements of the planning conditions in terms of noise. There may also be limitations as to the number of potential mitigation combinations that can be implemented at the site. As such, the curtailment strategy provided is not exhaustive and amendments can be expected depending on various site and turbine/machinery related specifics. The curtailment information provided here is only intended to demonstrate that the noise limits specified as part of the planning conditions can clearly be met in practice for the candidate turbine model considered here.

Table 10 shows the resultant predicted maximum turbine noise levels for any given wind direction with the curtailment strategy detailed above in place.

Table 10 - Maximum Predicted Turbine Noise Levels inc. Daytime Curtailment, dB L_{A90}

House ID	Standardised 10 m Height Wind Speed, m.s ⁻¹									
	3	4	5	6	7	8	9	10	11	12
H1	17.6	19.6	25.1	27.8	27.6	28.6	28.6	27.6	27.6	27.6
H2	12.5	14.6	20.1	23.0	23.5	23.5	23.5	23.5	23.5	23.5
H3	18.2	20.2	25.7	28.7	29.2	29.2	29.2	29.2	29.2	29.2
H4	20.0	22.0	27.5	30.1	30.3	31.0	31.0	30.3	30.3	30.3
H5	18.2	20.2	25.7	28.7	29.2	29.2	29.2	29.2	29.2	29.2
H6	13.7	15.7	21.2	24.2	24.7	24.7	24.7	24.7	24.7	24.7
H7	21.4	23.4	28.9	31.5	31.0	32.4	32.4	31.0	31.0	31.0
H8	17.1	19.1	24.6	27.4	27.5	28.1	28.1	27.5	27.5	27.5
H9	15.0	17.0	22.5	25.5	26.0	26.0	26.0	26.0	26.0	26.0
H10	8.9	10.9	16.4	19.4	19.9	19.9	19.9	19.9	19.9	19.9
H11	21.2	23.3	28.8	31.3	30.9	32.2	32.2	30.9	30.9	30.9
H12	6.5	8.5	14.0	17.0	17.5	17.5	17.5	17.5	17.5	17.5
H13	15.3	17.3	22.8	25.8	26.3	26.3	26.3	26.3	26.3	26.3
H14	18.3	20.3	25.8	28.4	27.9	29.3	29.3	27.9	27.9	27.9
H15	18.1	20.1	25.6	28.6	29.1	29.1	29.1	29.1	29.1	29.1

Table 11 shows the minimum margin of predicted compliance with the daytime noise limits detailed within the planning consent document for the development for any given wind direction and with the curtailment strategy detailed above in place. This demonstrates that the daytime planning condition noise limits can be met for all wind directions.

Table 11 - Minimum Margin of Compliance inc. Daytime Curtailment, dB

House ID	Standardised 10 m Height Wind Speed, m.s ⁻¹									
	3	4	5	6	7	8	9	10	11	12
H1	-9.9	-7.9	-4.5	-5.1	-1.5	-1.1	-7.1	-7.1	-7.1	-7.1
H2	-15.0	-12.9	-7.4	-5.4	-6.9	-7.1	-7.1	-7.1	-7.1	-7.1
H3	-9.3	-7.3	-3.9	-4.4	-5.5	-5.5	-5.5	-5.5	-5.5	-5.5
H4	-7.5	-6.3	-3.4	-1.2	-1.0	-1.1	-1.4	-1.5	-1.5	-1.5
H5	-9.3	-7.3	-4.3	-4.5	-6.1	-6.3	-6.3	-6.4	-6.4	-6.4
H6	-13.8	-11.8	-6.3	-3.5	-3.8	-2.8	-3.9	-5.1	-5.1	-5.1
H7	-6.1	-5.4	-1.3	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
H8	-10.4	-8.4	-4.4	-5.2	-1.1	-1.3	-7.0	-7.0	-7.0	-7.0
H9	-12.5	-10.5	-5.0	-2.3	-2.7	-1.5	-2.7	-3.8	-3.8	-3.8
H10	-18.6	-16.6	-11.1	-8.1	-7.6	-7.6	-7.6	-7.6	-7.6	-7.6
H11	-6.3	-5.6	-1.5	-0.1	-0.1	-0.2	-0.3	-0.2	-0.2	-0.2
H12	-21.0	-19.0	-13.5	-10.5	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0
H13	-12.2	-10.2	-4.7	-2.0	-2.2	-1.2	-2.4	-3.5	-3.5	-3.5
H14	-9.2	-7.2	-3.6	-3.8	-1.2	-1.0	-5.7	-5.7	-5.7	-5.7
H15	-9.4	-7.4	-4.4	-5.3	-6.8	-7.1	-7.1	-7.1	-7.1	-7.1

6. CONCLUSIONS

An assessment based on the consented site layout and relevant acoustic emission data for the Nordex 117 3.6 MW turbine with a 91.5 m hub height shows that the predicted operational noise levels for Upper Ogmere Wind Farm operating unrestricted are above the planning condition limits at some dwellings located to the southwest of the development and for certain wind directions. As a result, a mitigation/curtailment strategy has been determined that allows the noise limits to be met whilst maximizing the potential generating capacity of the site. The curtailment strategy provided is not exhaustive and amendments can be expected depending on various site and turbine/manufacturer specific limitations.

7. REFERENCES

- [1] Minister for Climate Change - Welsh Government, Letter Ref. qA1452991 - App Ref. DNS/3213662, 28th September 2022
- [2] International Organization for Standardization, ISO 9613-2 - Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation, 1996
- [3] Acoustics Bulletin, "Prediction and Assessment of Wind Turbine Noise, Agreement About Relevant Factors for Noise Assessment from Wind Energy Projects", Acoustics Bulletin Vol. 34 No. 2, March/April 2009
- [4] Institute of Acoustics, "A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise", May 2013
- [5] International Organization for Standardization, ISO 9613-1 - Acoustics - Attenuation of sound during propagation outdoors - Part 1: Calculation of the absorption of sound by the atmosphere, 1993
- [6] Nordex, "Noise level, Power curves, Thrust curves", Nordex N117/3600 Serrated Trailing Edge Operational Modes, Document Ref: F008_256_A13_EN Revision 09, 22 June 2021
- [7] Nordex, "Octave sound power levels", Nordex N117/3600 Serrated Trailing Edge - Operational Modes, Document Ref: F008_256_A17_EN, Revision 02, 22 June 2021

APPENDIX A - DECISION NOTICE & PLANNING CONDITIONS

APPENDIX B - ORIGINAL ACOUSTIC ASSESSMENT