Technical Appendix

Drummarnock Wind Farm

Technical Appendix 11-4: Noise Mitigation Strategy

Drummarnock Wind Farm Limited

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1 Noise Mitigation Strategy

The curtailment strategy set out below is the calculated noise mitigation required in order to meet the applicable noise limits at one receptor, Ryecroft. Note that no curtailment would be required in the scenario that this property was financially involved in the Proposed Development.

Curtailment is set out with reference to both wind direction (angular degrees relative to north) and wind speed (ranging from 4 m/s to 12 m/s standardised to 10 m height) and specifies the operational modes that each turbine should use for each scenario.

The purpose of this curtailment strategy is to demonstrate the feasibility of achieving the noise limits based on the existing design of the Proposed Development. The mitigation strategy used in practice will depend upon the turbine model installed on site, which may not be the same as the candidate turbine model (Nordex N163) used for the Proposed Development's noise predictions. In addition, a +2 dB uncertainty value has been assumed as part of the predicted noise level calculations (see Appendix 11-1 Noise Prediction Methodology), which may in practice result in less curtailment to be required.

The Nordex N163 specification identifies modes of operation starting with Mode 1 (power-optimised, no noise reduction), with Modes 2 to 16 representing varying levels of noise-reduced modes of operation. A final Mode, 'Off', is also considered, whereby the turbine is shut down. Sound power levels by wind speed are shown below for the Nordex N163 6.8 MW STE mitigation Modes 1 to 3 and 9 to 16, based on noise specification data for the 138 m hub-height. Modes 4 to 8 are not available in the 138 m hub-height model and are therefore not presented and their use is avoided in the determination of the mitigation strategy.

For calculation purposes, sound powers are adjusted to a standardised 10 m wind speed based on the design hub-height for the development of 98.5 m. Resulting overall sound power levels for each operational mode, including a +2 dB uncertainty value, are set out against standardised wind speeds in Table A4-1.

Table A4-1: Nordex N163 Mitigation Mode Sound Power Levels

10m Wind Speed (m/s)	Overall Sound Power Level by Operational Mode, dB(A)										
	1	2	3	9	10	11	12	13	14	15	16
4	98.7	98.7	98.7	98.9	98.9	99.0	99.0	99.0	98.7	98.7	98.7
5	102.8	102.8	102.8	103.2	103.2	103.3	103.2	103.1	102.1	101.8	101.4
6	107.1	106.9	106.6	106.3	105.9	105.6	105.2	104.8	103.0	102.5	102.0
7	108.3	108.0	107.5	107.0	106.5	106.0	105.5	105.0	103.0	102.5	102.0
8	108.4	108.0	107.5	107.0	106.5	106.0	105.5	105.0	103.0	102.5	102.0
9	108.4	108.0	107.5	107.0	106.5	106.0	105.5	105.0	103.0	102.5	102.0
10	108.4	108.0	107.5	107.0	106.5	106.0	105.5	105.0	103.0	102.5	102.0
11	108.4	108.0	107.5	107.0	106.5	106.0	105.5	105.0	103.0	102.5	102.0
12	108.4	108.0	107.5	107.0	106.5	106.0	105.5	105.0	103.0	102.5	102.0

The operational mode for a given scenario is determined based on an iterative process of reducing the mode of operation to a quieter mode for the most contributing turbine at the critical receptor location (i.e. the location with the greatest exceedance of the

applicable limits). The process is repeated until the required sound levels are met at all locations. In some instances where the most contributing turbine is in Mode 3 or Mode 16 (and therefore the next mode is a relatively large step-change to Mode 9 or to switch the turbine off) and the remaining noise reduction is relatively small, the remaining noise reduction may be achieved by reducing noise from other turbines instead.

To avoid the need for unnecessary mitigation in marginal situations, an allowance is made whereby if the cumulative noise limit is exceeded by less than 0.5 dB, further mitigation is not considered to be necessary.

The applied limits are based upon the calculated Remaining Noise Budget (RNB) (see Table 11-11 in the Noise chapter). The RNB is calculated based on the anticipated noise levels from other developments, the reasonable worst-case noise levels from other developments (whereby an additional uncertainty uplift has been applied), and the applicable cumulative noise limits of 40 dB during the daytime, 43 dB during the night-time, and 45 dB at all times for financially involved properties. It should be noted that only one receptor (Ryecroft, which is assumed to be not financially involved in the project) results in noise mitigation requirements, and only during the daytime.

Note that for all RNB and curtailment calculations, the calculations are performed without rounding, with input values using a minimum precision of one decimal place, whereas all results are presented to the nearest integer value.

The predicted directional noise levels for each receptor without mitigation are shown in Table A4-2, while the calculated RNB values (see Table 11-12 in the Noise chapter) are also reproduced for reference as Table A4-3. Where the predicted noise levels exceed the RNB, the difference between these values indicates the required mitigation reduction for each wind direction, and is shown in **Table A4-2** (where the predicted noise levels are equal to or below the RNB, a zero is shown).

Table A4-2: Proposed Development directional noise levels without mitigation (dB L_{A90})

Location	Wind Direction, °	Standardised 10m height wind speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
Ryecroft	0	22	24	28	33	34	34	34	34	34	34
	30	25	26	31	35	36	36	36	36	36	36
	60	27	29	33	37	39	39	39	39	39	39
	90	28	30	34	38	40	40	40	40	40	40
	120	28	30	34	38	40	40	40	40	40	40
	150	28	30	34	38	40	40	40	40	40	40
	180	28	30	34	38	40	40	40	40	40	40
	210	28	30	34	38	39	39	39	39	39	39
	240	27	29	33	37	39	39	39	39	39	39
	270	25	27	31	35	37	37	37	37	37	37
	300	23	25	29	33	34	34	34	34	34	34
	330	22	24	28	32	33	33	33	33	33	33

Table A4-3: Daytime RNB values (dB L_{A90})

Location	Wind Direction, °	Standardised 10m height wind speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
Ryecroft	0	40	40	39	39	39	39	38	38	38	38
	30	40	40	40	39	39	39	39	39	39	39
	60	40	40	40	39	39	39	39	39	39	39
	90	39	39	39	39	39	38	38	38	38	38
	120	38	38	38	38	38	36	35	35	35	35
	150	38	38	38	38	38	36	34	34	34	34
	180	38	38	38	38	37	35	33	33	33	33
	210	38	38	37	37	37	34	31	30	31	31
	240	38	38	37	36	36	32	30	30	30	30
	270	38	38	38	37	36	34	32	31	32	32
	300	39	39	39	38	38	37	37	37	37	37
	330	40	40	39	39	38	38	38	38	38	38

Table A4-4: Required reduction to meet RNB values (dB L_{A90})

Location	Wind Direction, °	Standardised 10m height wind speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
Ryecroft	0	0	0	0	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0	0	0	0
	60	0	0	0	0	0	0	0	0	0	0
	90	0	0	0	0	1	1	2	2	2	2
	120	0	0	0	0	2	3	5	5	5	5
	150	0	0	0	1	2	4	5	6	6	6
	180	0	0	0	1	2	4	6	7	6	6
	210	0	0	0	1	3	5	8	9	8	8
	240	0	0	0	1	3	7	9	9	9	9
	270	0	0	0	0	0	2	5	5	5	5
	300	0	0	0	0	0	0	0	0	0	0
	330	0	0	0	0	0	0	0	0	0	0

The mitigation modes for each turbine for each wind speed and direction are set out in Table A4-5 to Table A4-8. It is noted that no curtailment is identified to be required during the night-time period.

Table A4-5: Daytime Curtailment Operational Modes – T1

Wind Speed (m/s)	Wind Direction (°)											
	0	30	60	90	120	150	180	210	240	270	300	330
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	3	9	9	9	1	1	1
7	1	1	1	3	9	9	9	9	9	1	1	1
8	1	1	1	9	9	10	11	14	16	9	1	1
9	1	1	1	9	11	11	15	16	16	13	1	1

Wind Speed (m/s)	Wind Direction (°)											
	0	30	60	90	120	150	180	210	240	270	300	330
10	1	1	1	9	11	14	16	Off	16	14	1	1
11	1	1	1	9	11	13	15	16	16	13	1	1
12	1	1	1	9	11	13	15	16	16	13	1	1

Table A4-6: Daytime Curtailment Operational Modes – T2

Wind Speed (m/s)	Wind Direction (°)											
	0	30	60	90	120	150	180	210	240	270	300	330
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	3	9	9	1	1	1
10	1	1	1	1	1	2	9	9	9	1	1	1
11	1	1	1	1	1	1	3	9	9	1	1	1
12	1	1	1	1	1	1	3	9	9	1	1	1

Table A4-7: Daytime Curtailment Operational Modes – T3

Wind Speed (m/s)	Wind Direction (°)											
	0	30	60	90	120	150	180	210	240	270	300	330
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	9	9	9	9	9	1	1	1
9	1	1	1	1	9	9	9	16	16	2	1	1
10	1	1	1	1	9	9	9	9	16	9	1	1
11	1	1	1	1	9	9	9	16	16	2	1	1
12	1	1	1	1	9	9	9	16	16	2	1	1

Table A4-8: Daytime Curtailment Operational Modes – T4

Wind Speed (m/s)	Wind Direction (°)											
	0	30	60	90	120	150	180	210	240	270	300	330
4	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	2	2	9	3	1	1	1	1

Wind Speed (m/s)	Wind Direction (°)											
	0	30	60	90	120	150	180	210	240	270	300	330
9	1	1	1	1	9	9	9	10	9	1	1	1
10	1	1	1	1	9	9	9	9	9	1	1	1
11	1	1	1	1	9	9	9	10	9	1	1	1
12	1	1	1	1	9	9	9	10	9	1	1	1

The predicted directional noise levels after the adoption of mitigation are shown for each receptor in Table A4-9. The difference between these values and the RNB is shown in Table A4-10. Note that zero and negative values indicate that the limit is met.

Table A4-9: Predicted directional noise levels with mitigation (dB L_{A90})

Location	Wind Direction, °	Standardised 10m height wind speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
Ryecroft	0	22	24	28	33	34	34	34	34	34	34
	30	25	27	31	35	36	36	36	36	36	36
	60	27	29	33	37	39	39	39	39	39	39
	90	28	30	34	38	39	38	38	38	38	38
	120	28	30	34	38	38	36	35	35	35	35
	150	28	30	34	38	38	36	35	34	34	34
	180	28	30	34	37	38	35	34	33	34	34
	210	28	30	34	36	37	35	31	30	31	31
	240	27	29	33	35	36	33	30	30	30	30
	270	25	27	31	35	37	33	32	30	32	32
	300	23	25	29	33	34	34	34	34	34	34
	330	22	24	28	32	33	34	34	34	34	34

Table A4-10: Difference between mitigated noise levels and RNB values (dB L_{A90})

Location	Wind Direction, °	Standardised 10m height wind speed (m/s)									
		3	4	5	6	7	8	9	10	11	12
Ryecroft	0	-17	-15	-11	-6	-5	-5	-4	-4	-4	-4
	30	-15	-13	-9	-4	-3	-3	-3	-3	-3	-3
	60	-13	-11	-7	-2	-1	-1	0	0	0	0
	90	-11	-9	-5	-1	0	-1	-1	0	-1	-1
	120	-10	-8	-4	0	0	0	0	0	0	0
	150	-10	-8	-4	0	0	0	0	0	0	0
	180	-10	-8	-4	-1	0	-1	0	0	0	0
	210	-10	-8	-4	-1	0	0	0	0	0	0
	240	-11	-9	-4	-1	0	0	0	0	0	0
	270	-13	-11	-7	-1	0	-1	0	-1	0	0
	300	-17	-15	-10	-5	-4	-3	-3	-3	-3	-3
	330	-18	-16	-12	-7	-5	-5	-5	-5	-5	-5