



Dudgeon and Sheringham Shoal Offshore Wind Farm Extensions

Preliminary Environmental Information Report

Volume 3

Appendix 25.5 - Onshore Substation Zone Operational
Noise Assessment

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Glossary of Acronyms

BDC	Broadland District Council
BS	British Standard
DEP	Dudgeon Extension Project
LOAEL	Lowest Observed Adverse Effect Level
NNG	Night Noise Guidance
NOEL	No Observed Effect Level
NPSE	Noise Policy Statement England
NSR	Noise Sensitive Receptor
PEIR	Preliminary Environmental Information Report
PPG	Planning Practice Guidance
SEP	Sheringham Shoal Extension Project
SGT	Super Grid Transformer
SHR	Shunt Reactor
SNC	South Norfolk Council
SOAEL	Significant Observed Adverse Effect Level

Glossary of Terms

The Applicant	Equinor New Energy Limited
Dudgeon Offshore Wind Farm Extension site	The Dudgeon Offshore Wind Farm Extension offshore wind farm boundary.
The Dudgeon Offshore Wind Farm Extension Project (DEP)	The Dudgeon Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.
Sheringham Shoal Offshore Wind Farm Extension site	Sheringham Shoal Offshore Wind Farm Extension offshore wind farm boundary.
The Sheringham Shoal Offshore Wind Farm Extension Project (SEP)	The Sheringham Offshore Wind Farm Extension site as well as all onshore and offshore infrastructure.

25.3 ONSHORE SUBSTATION OPERATIONAL NOISE ASSESSMENT

25.3.1 Introduction

1. This appendix of the Preliminary Environmental Information Report (PEIR) of the proposed Dudgeon Offshore Wind Farm Extension Project (DEP) and Sheringham Shoal Offshore Wind Farm Extension Project (SEP) details the approach undertaken for the operational noise assessment at the identified Noise Sensitive Receptor (NSR) locations surrounding the onshore substation site options.

25.3.2 Assessment Criteria

2. Noise impacts associated with operation of the onshore substation were assessed in accordance with the guidance provided in BS 4142; determining the level of impact based on the difference between the predicted rating level, $L_{Ar,T}$, against the existing background sound level, L_{A90} .
3. It is stated in section 11 of BS 4142 that:

“Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night.”
4. Therefore, additional criteria are considered in the impact assessment based on the absolute noise level associated with the onshore substation site options.
5. The WHO Night Noise Guidance for Europe (NNG) found that below the level of 30 dBA $L_{night,outside}$ there are no observed effects on sleep. Furthermore, there is no evidence that biological effects observed at levels below 40 dBA $L_{night,outside}$ are harmful to health. At levels above 55 dBA $L_{night,outside}$, the NNG detailed that adverse health effects occur frequently and there is limited evidence that the cardio-vascular system is coming under stress.
6. Therefore, based on the NNG, the following effect levels for assessing against the NPSE categories are also relevant:
 - <30 dBA $L_{night,outside}$ - no observed effect level (NOEL);
 - <40 dBA $L_{night,outside}$ - lowest observed adverse effect level (LOAEL); and
 - >55 dBA $L_{night,outside}$ - significant observed adverse effect level (SOAEL).
7. **Table 25.3.1** outlines the magnitude of effect criteria used in the assessment of operational noise associated with the onshore substation site options.

Table 25.3.1: Operational noise magnitude of effect criteria

Rating level ($L_{Ar,Tr}$ dB)	Magnitude of effect	NPSE/PPG category using BS 4142 criteria	WHO NNG threshold	NPSE/PPG category using WHO NNG threshold
\leq Measured L_{A90}	No Impact	NOEL	<30 dBA $L_{night,outside}$	NOEL
= Measured L_{A90} dB to + 2.9 dB	Negligible	LOAEL	<40 dBA $L_{night,outside}$	LOAEL

Rating level (L _{Ar,Tr} dB)	Magnitude of effect	NPSE/PPG category using BS 4142 criteria	WHO NNG threshold	NPSE/PPG category using WHO NNG threshold
Measured L _{A90} + 3 dB to 4.9 dB	Low	OAE		
Measured L _{A90} + 5 dB to 9.9 dB	Medium	SOAEL	>55 dBA L _{night,outside}	SOAEL
≥ Measured L _{A90} + 10 dB	High	UAE		

25.3.3 Existing Environment

25.3.3.1 NSR Locations

8. A total of 10 NSR locations were agreed as part of consultation with Broadland District Council (BDC) and South Norfolk Council (SNC) for DEP and SEP; presented in **Table 25.3.2**.

Table 25.3.2: Onshore substation site options noise sensitive receptors included in assessment

NSR identifier	Coordinates		Classification	Sensitivity
	X	Y		
SSR1	620863	302329	Residential	Medium
SSR2	621180	301320	Residential	Medium
SSR3	621610	301271	Residential	Medium
SSR4	620339	301806	Residential	Medium
SSR5	622499	302482	Residential	Medium
SSR6	622529	302038	Residential	Medium
SSR7	621575	302924	Residential	Medium
SSR8	621319	303086	Residential	Medium
SSR9	620982	301753	Residential	Medium
SSR10	620997	301476	Residential	Medium

25.3.3.2 Baseline Noise Environment

9. Consultation was undertaken with BDC and SNC to agree the baseline survey approach in light of the COVID-19 pandemic.
10. It was agreed that the effects from reduced transportation sources and the countrywide lockdown due to government COVID-19 restrictions would have an effect on the current baseline noise levels at all receptors within the vicinity of the onshore substation footprint/study area and therefore the survey should be postponed until 'normal' conditions are resumed.
11. It was also agreed that the use of published baseline survey data used to support the Hornsea Project Three Environmental Statement would be suitable for the purposes of determining the background noise level (L_{A90}) for the operational phase assessment at PEI stage.
12. It is proposed that an additional baseline noise survey will be undertaken to support the Environmental Statement for DEP and SEP.
13. The measured baseline noise levels utilised at each NSR location are detailed in **Table 25.3.3**.

Table 25.3.3: Measured baseline sound levels, onshore substation site options

NSR identifier	L _{Aeq,T} (dB)	L _{AFmax} (dB)	L _{A10} (dB)	L _{A90} (dB)
Daytime (07:00 - 23:00)				
SSR1	43	84	46	33
SSR2	43	84	46	33
SSR3	53	87	47	36
SSR4	43	84	46	33
SSR5	61	90	63	50
SSR6	61	90	63	50
SSR7	53	87	47	36
SSR8	53	87	47	36
SSR9	43	84	46	33
SSR10	43	84	46	33
Night-time (23:00 - 07:00)				
SSR1	40	85	43	28
SSR2	40	85	43	28
SSR3	48	99	44	29

NSR identifier	L _{Aeq,T} (dB)	L _{AFmax} (dB)	L _{A10} (dB)	L _{A90} (dB)
SSR4	40	85	43	28
SSR5	55	91	59	29
SSR6	55	91	59	29
SSR7	48	99	44	29
SSR8	48	99	44	29
SSR9	40	85	43	28
SSR10	40	85	43	28

25.3.4 Operational Noise Assessment Assumptions

25.3.4.1 Onshore Substation Layout

14. Two separate options for the onshore substation site layout were considered in the operational noise phase noise assessment:
 - Site 1; and
 - Site 2.
15. Details for both site options were provided were provided by the Applicant's onshore substation design contractor and consider both DEP and SEP in combination. This is considered a worst case for potential noise impacts.

25.3.4.2 Operational Noise Sources

16. Operational noise sources that were implemented into the noise model are identified in **Table 25.3.4** and their respective frequency spectra are presented in **Table 25.3.5**.
17. The noise modelling assumes the same components and component quantity for both Site 1 and Site 2.

Table 25.3.4: Operational noise sources

Component ID	Component	Component quantity	Sound power level (dBA)	Equipment height (m)	Associated spectra
1	SGT Tank & Cooler (3-Phase)	2	95	6.0	SNS1
2	400kV Filter Capacitor Bank	6	79	8.5	SNS10
3	400kV Filter Air Core Reactor	6	87	4.5	SNS2
4/5	220kV Filter Capacitor Bank	12	79	8.5	SNS10
6/7	220kV Filter Air Core Reactor	12	87	4.5	SNS2
8	SVC Ph. Air Core Reactor	6	87	4.5	SNS3
9/10	MSR Air Core Reactor	9	84	5.2	SNS4
11/12	220kV SHR	6	89	12.0	SNS5
13	EPVT	3	40	4.5	SNS6
14	SVC Cooler	1	76	2.6	SNS7
15	SVC Building A/C Unit	5	80	2.0	SNS8
16	Control Room Building A/C Unit	10	80	2.0	SNS9

Table 25.3.5: Operational noise source spectra

Noise level (dBA)							
63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
SNS1							
58.0	88.0	91.4	82.0	67.4	57.3	46.0	34.6
SNS2							
62.0	82.0	76.0	85.0	66.0	55.0	-	-
SNS3							
30.0	85.0	59.0	74.0	79.0	52.0	-	-
SNS4							
23.0	85.0	69.0	83.0	29.0	-	-	-
SNS5							
-	89.0	-	-	-	-	-	-
SNS6							
-	-	-	-	40.0	-	-	-
SNS7							

Noise level (dBA)																				
63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz													
-	-	-	-	76.0	-	-	-													
SNS8																				
58.8	73.9	68.4	73.8	76.0	74.2	67.0	63.9													
SNS9																				
48.8	59.9	58.4	73.8	70.0	69.2	68.0	52.9													
Noise level (dBA)																				
63Hz	80Hz	100Hz	125Hz	160Hz	200Hz	250Hz	315Hz	400Hz	500Hz	630Hz	800Hz	1kHz	1.25kHz	1.6kHz	2kHz	2.5kHz	3.15kHz	4kHz	5kHz	6.3kHz
SNS10																				
30	30	65	30	49	70	57	77	61	66	60	51	50	30	30	30	30	30	30	30	30

25.3.4.3 Noise Modelling Assumptions and Methodology

18. Noise levels associated with DEP and SEP onshore substation were predicted at the identified NSR locations using SoundPLAN modelling software. The software implements accepted national and international acoustic calculation standards.
19. Operational noise modelling predictions were undertaken in accordance with the methodology provide in ISO 9613-2; accounting for spherical propagation, air absorption, ground absorption and acoustic screening due to intervening buildings and structures between the NSR locations and noise sources at the onshore substation site options.
20. A three-dimensional model was created using geo-referenced OS mapping data, topographical data of the local area incorporating buildings, plans and elevations of the site.
21. Daytime predictions were undertaken at the ground floor level and night-time predictions were undertaken at first floor level, 1.5m and 4.0m respectively.
22. Ground surfaces within the study area are generally considered 'soft' such as the agricultural and grassland areas in the intervening area between the onshore substation sites and the NSRs. Therefore, an assumed ground factor of 0.9 was employed outside the onshore substation site options. Inside the onshore substation site options, a ground factor of 0.5 was implemented into the model to account for the surfacing withing the compound.
23. All components outlined in **Table 25.3.4** are considered steady noise sources that continuously operate with no intermittent or impulsive noise characteristics; therefore, no penalty for intermittency or impulsivity were included in the predicted rating level, $L_{A,T}$, at the NSRs.
24. A review of tonal characteristics at the NSRs was undertaken to determine likely perceptibility. Where potential tonality was identified, the absolute noise level contributions at those frequencies were identified to be generally less than 20 dBA. Therefore, it is considered unlikely that tonality will be perceptible at the NSRs and accordingly no acoustic correction has been applied.

25.3.5 Predicted Operational Noise Levels

25. This section outlines the predicted noise levels and the respective magnitude of effect at each NSR for Site 1 and Site 2.
26. Site 1 - DEPSEP-SIE-02-XX-LY-EP-0003 (OPTION 2)-200MX225M PLOT
27. Site 2 - DEPSEP-SIE-02-XX-LY-EP-0103 (OPTION 2)-285MX145M PLOT

25.3.5.1 Site 1

28. The predicted noise level at each NSR for the unmitigated noise levels are presented in **Table 25.3.6**.

Table 25.3.6: Operational noise assessment - Site 1, unmitigated

NSR identifier	Predicted noise level (dB L _{Aeq,T})	Background sound level (dB L _{A90})	Acoustic characteristic correction	Rating level (dB L _{Ar,T})	Difference between rating level and background sound level	Magnitude of effect (BS 4142 criteria)	Magnitude of effect (NNG criteria)
Daytime (07:00 - 23:00)							
SSR1	28.5	33	0	28.5	-4.5	No impact	N/A
SSR2	30.9	33	0	30.9	-2.1	No impact	N/A
SSR3	33.6	36	0	33.6	-2.4	No impact	N/A
SSR4	25.4	33	0	25.4	-7.6	No impact	N/A
SSR5	30.2	50	0	30.2	-19.8	No impact	N/A
SSR6	33.3	50	0	33.3	-16.7	No impact	N/A
SSR7	28.0	36	0	28.0	-8.0	No impact	N/A
SSR8	26.8	36	0	26.8	-9.2	No impact	N/A
SSR9	30.5	33	0	30.5	-2.5	No impact	N/A
SSR10	29.7	33	0	29.7	-3.3	No impact	N/A
Night-time (23:00 - 07:00)							

NSR identifier	Predicted noise level (dB L _{Aeq,T})	Background sound level (dB L _{A90})	Acoustic characteristic correction	Rating level (dB L _{Ar,T})	Difference between rating level and background sound level	Magnitude of effect (BS 4142 criteria)	Magnitude of effect (NNG criteria)
SSR1	29.7	28	0	29.7	+1.7	Negligible	No impact
SSR2	32.7	28	0	32.7	+4.7	Low	Low
SSR3	34.6	29	0	34.6	+5.6	Medium	Low
SSR4	26.4	28	0	26.4	-1.6	No impact	No impact
SSR5	31.0	29	0	31.0	+2.0	Negligible	Low
SSR6	34.1	29	0	34.1	+5.1	Medium	Low
SSR7	28.8	29	0	28.8	-0.2	No impact	No impact
SSR8	27.8	29	0	27.8	-1.2	No impact	No impact
SSR9	31.7	28	0	31.7	+3.7	Low	Low
SSR10	30.6	28	0	30.6	+2.6	Negligible	Low

29. From **Table 25.3.6** it is seen that the predicted daytime rating levels are below the existing daytime background sound level at all NSRs; indicating a magnitude of effect of no impact during the daytime.
30. During the night-time the predicted rating level is +5dB above the existing background sound level at SSR3 and SSR6; indicating a magnitude of effect of medium when using the BS 4142 criteria.
31. Detailed analysis of the predicted noise levels at NSRs indicate that noise associated with Super Grid Transformer (SGT) and Shunt Reactor (SHR) components are the dominant contributors of noise from the onshore substation.
32. Mitigation measures to reduce the predicted night-time rating level include attenuating the SGT and SHRs to achieve a source noise levels of 80 dB L_{WA}.
33. The predicted noise level at each NSR for the mitigated noise levels are presented in **Table 25.3.7**.

Table 25.3.7: Operational noise assessment - Site 1, mitigated

NSR identifier	Predicted noise level (dB L _{Aeq,T})	Background sound level (dB L _{A90})	Acoustic characteristic correction	Rating level (dB L _{Ar,T})	Difference between rating level and background sound level	Magnitude of effect (BS 4142 criteria)	Magnitude of effect (NNG criteria)
Night-time (23:00 - 07:00)							
SSR1	25.7	28	0	25.7	-2.3	No impact	No impact
SSR2	29.4	28	0	29.4	+1.4	Negligible	No impact
SSR3	30.9	29	0	30.9	+1.9	Negligible	Low
SSR4	22.2	28	0	22.2	-5.8	No impact	No impact
SSR5	27.2	29	0	27.2	-1.8	No impact	No impact
SSR6	30.4	29	0	30.4	+1.4	Negligible	Low
SSR7	25.2	29	0	25.2	-3.8	No impact	No impact
SSR8	23.8	29	0	23.8	-5.2	No impact	No impact
SSR9	27.7	28	0	27.7	-0.3	No impact	No impact
SSR10	26.4	28	0	26.4	-1.6	No impact	No impact

34. From **Table 25.3.7** it is seen that negligible magnitude of effect, at worst, is predicted at all NSRs during the night-time.

25.3.5.2 Site 2

35. The predicted noise level at each NSR for the unmitigated noise levels are presented in **Table 25.3.8**.

Table 25.3.8: Operational noise assessment - Site 2, unmitigated

NSR identifier	Predicted noise level (dB L _{Aeq,T})	Background sound level (dB L _{A90})	Acoustic characteristic correction	Rating level (dB L _{Ar,T})	Difference between rating level and background sound level	Magnitude of effect (BS 4142 criteria)	Magnitude of effect (NNG criteria)
Daytime (07:00 - 23:00)							
SSR1	35.1	33	0	35.1	+2.1	Negligible	N/A
SSR2	30.5	33	0	30.5	-2.5	No impact	N/A
SSR3	30.0	36	0	30.0	-6.0	No impact	N/A
SSR4	28.1	33	0	28.1	-4.9	No impact	N/A
SSR5	28.3	50	0	28.3	-21.7	No impact	N/A
SSR6	28.6	50	0	28.6	-21.4	No impact	N/A
SSR7	32.6	36	0	32.6	-3.4	No impact	N/A
SSR8	30.7	36	0	30.7	-5.3	No impact	N/A
SSR9	33.8	33	0	33.8	+0.8	Negligible	N/A
SSR10	30.5	33	0	30.5	-2.5	No impact	N/A
Night-time (23:00 - 07:00)							
SSR1	36.2	28	0	36.2	+8.2	Medium	Low
SSR2	32.6	28	0	32.6	+4.6	Low	Low

NSR identifier	Predicted noise level (dB L _{Aeq,T})	Background sound level (dB L _{A90})	Acoustic characteristic correction	Rating level (dB L _{Ar,T})	Difference between rating level and background sound level	Magnitude of effect (BS 4142 criteria)	Magnitude of effect (NNG criteria)
SSR3	31.5	29	0	31.5	+2.5	Negligible	Low
SSR4	29.4	28	0	29.4	+1.4	Negligible	No impact
SSR5	29.3	29	0	29.3	+0.3	Negligible	No impact
SSR6	29.5	29	0	29.5	+0.5	Negligible	No impact
SSR7	34.5	29	0	34.5	+5.5	Medium	Low
SSR8	33.0	29	0	33.0	+4.0	Low	Low
SSR9	34.8	28	0	34.8	+6.8	Medium	Low
SSR10	31.7	28	0	31.7	+3.7	Low	Low

36. From **Table 25.3.8** it is seen that the predicted rating levels are of negligible magnitude of effect, at worst, during the daytime at all NSRs.
37. During the night-time the predicted rating level is +5dB above the existing background sound level at SSR1, SSR7 and SSR9; indicating a magnitude of effect of medium when using the BS 4142 criteria.
38. Detailed analysis of the predicted noise levels at NSRs indicate that noise associated with the SGT, SHRs and 220kV and 400kV Filter Air Core Reactors (ACRs) are the dominant contributors of noise from the onshore substation.
39. Mitigation measures to reduce the predicted night-time rating level include attenuating the SGT and SHRs to achieve a source noise levels of 80 dB L_{WA} and attenuating the 220kV and 400kV Filter ACRs to achieve a source noise level of 82 dB L_{WA}.
40. The predicted noise level at each NSR for the mitigated noise levels are presented in **Table 25.3.9**.

Table 25.3.9: Operational noise assessment - Site 2, mitigated

NSR identifier	Predicted noise level (dB L _{Aeq,T})	Background sound level (dB L _{A90})	Acoustic characteristic correction	Rating level (dB L _{Ar,T})	Difference between rating level and background sound level	Magnitude of effect (BS 4142 criteria)	Magnitude of effect (NNG criteria)
Night-time (23:00 - 07:00)							
SSR1	31.0	28	0	31.0	+3.0	Low	Low
SSR2	26.8	28	0	26.8	-1.2	No impact	No impact
SSR3	26.5	29	0	26.5	-2.5	No impact	No impact
SSR4	23.9	28	0	23.9	-4.1	No impact	No impact
SSR5	23.6	29	0	23.6	-5.4	No impact	No impact
SSR6	24.0	29	0	24.0	-5.0	No impact	No impact
SSR7	28.9	29	0	28.9	-0.1	No impact	No impact
SSR8	27.9	29	0	27.9	-1.1	No impact	No impact
SSR9	29.3	28	0	29.3	+1.3	Negligible	No impact
SSR10	25.6	28	0	25.6	-2.4	No impact	No impact

41. From **Table 25.3.7** it is seen that low magnitude of effect, at worst, is predicted at all NSRs during the night-time.

25.3.6 Summary

42. Operational noise impacts were assessed in accordance with the guidance provided in BS 4142:2014+A1:2019 for the proposed DEP and SEP onshore substation for the two potential site layouts.
43. Mitigation will involve a combination of attenuation and design refinement of components to achieve the required levels. Mitigation measures were provided for both Site 1 and Site 2 in order to minimise potential noise impacts at nearby NSRs and include:
- Attenuation of the Super Grid Transformer (SGT) components to achieve a source noise level of 80 dB L_{WA} (Site 1 and Site 2);
 - Attenuation of the Shunt Reactor (SHR) components to achieve a source noise level of 80 dB L_{WA} (Site 1 and Site 2); and
 - Attenuation of the 220kV and 400kV Filter Air Core Reactors to achieve a source noise level of 82 dB L_{WA} (Site 2 only).
44. After implementation of the proposed mitigation measures for Site 1, a negligible magnitude of effect, at worst, is predicted at onshore substation site options NSRs.
45. For Site 2 low magnitude of effect, at worst, is predicted after implementation of the proposed mitigation measures.

25.3.7 References

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