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Horns Rev 3 Offshore Wind Farm

Technical report no. 20

OFFSHORE NOISE EMISSION

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Horns Rev 3 Offshore Wind Farm

OFFSHORE NOISE EMISSION

Client	Energinet.dk Att. Indkøb Tonne Kjærsvej 65 7000 Fredericia
Consultant	Orbicon A/S Ringstedvej 20 4000 Roskilde
Sub-consultants	Royal Hakoning DHV Marlborough House Marlborough Crescent Newcastle upon Tyne NE1 4EE, United Kingdom

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Prepared by	Stephen Wigham
Reviewed by	Dean Curtis, Simon B. Leonhard
Approved by	Kristian Nehring Madsen
Cover photo	Jens Christensen
Photos	Unless specified © Orbicon A/S – Energinet.dk
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SUMMARY

This report presents an estimation of airborne noise emissions associated with the construction, operation and decommissioning phases of Horns Rev 3 Offshore Wind Farm. Estimates were based on the 3 MW turbine option as this is considered to represent the worst case in terms of noise emissions. Noise impacts were estimated for two scenarios: 1) for wind turbines supported by monopile foundations, and 2) for wind turbines supported by gravity base foundations.

With appropriate controls and management in place, emissions from the construction activities will have no greater than a negligible and temporary impact. During the operational phase of the development, offshore noise effects will be negligible

SAMMENFATNING

Denne rapport indeholder en vurdering af støj i forbindelse med anlægs-, drifts- og nedlukningsfaserne af Horns Rev 3 Havmøllepark. Vurderingerne er baseret på optionen med 3 MW mølle, da denne anses for at repræsentere det værste scenarie i relation til støjemissioner. Støjpåvirkningerne blev vurderet ud fra to scenarier: 1) for vindmøller med monopælsfundamenter, og 2) for vindmøller med gravitationsfundamenter.

Med passende kontrol og miljøforvaltning vil støjemissionerne fra anlægsaktiviteterne ikke overstiger en ubetydelig og midlertidig effekt. I driftsfasen vil støjpåvirkninger offshore være ubetydelig.

Construction of an offshore wind farm – Horns rev 2

1. INTRODUCTION

This chapter of the draft Environmental Statement (ES) describes the existing offshore environment with regard to noise and vibration and assesses the potential impacts of Horns Rev3 during the construction, operation and decommissioning phases of the offshore infrastructure (wind turbines, converter station and cable installation). Where the potential for impacts is identified, mitigation measures and residual impacts are presented.

Subsea noise and vibration impacts associated with the construction, operation and decommissioning of the wind turbines is discussed in the report on fish ecology, benthic habitats and communities as well as marine mammals (Orbicon, 2014a; Orbicon, 2014b; Orbicon, 2014c). Given the separation distance of the offshore development and the nearest onshore coastal receptors an assessment of air borne noise associated with the offshore development along coastal areas has not been included in this assessment. Potential noise impacts upon terrestrial ecology receptors are discussed in the report on terrestrial interests (Orbicon, 2014d).

The Horns Rev 3 offshore wind farm will have an installed power of approximately 400 MW. The number and size of turbines installed has not been finalized, however three options are currently under consideration as outlined in Table 1.1.

Table 1.1. Horns Rev 3 Wind turbine installation options under consideration.

Turbine Size (MW)	Number of turbines	Installed Power (MW)
3	136	408
8	52	416
10	42	420

It is likely that turbine size will not affect the type of vessels used during construction of Horns Rev 3. However, it is assumed that the number of turbines requiring installation will affect the time in service for each vessel (i.e. more turbines will take longer to install). Therefore the 3 MW turbine option detailed in Table 1.1 represents the worst case in terms of total noise impact from marine vessels. Impact was therefore estimated based on the 3 MW turbine option.

The wind turbines will be supported by foundations fixed to the seabed. The type of foundations to be used for Horns Rev 3 has not yet been determined. However, fully commissioned wind farms Horns Rev 1 and 2, and Anholt offshore wind farm all used driven steel monopile foundations for the turbines. It is therefore likely that monopile foundations will be used for Horns Rev 3. Nevertheless, an assessment of noise emissions associated with both scenarios was made.

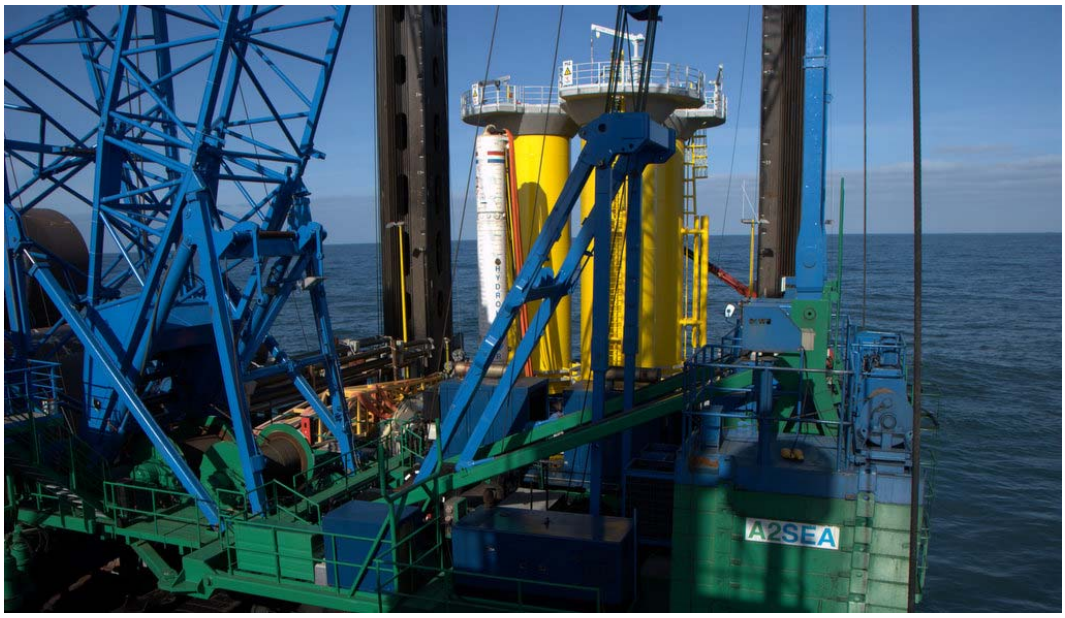
2. GUIDANCE AND CONSULTATION

2.1. Policy and Guidance

The noise assessment has been undertaken with specific reference to relevant national and/or international documents. In the absence of specific technical guidance and other relevant environmental guideline documentation produced by Danish authorities, information and guidance from other sources has been referenced as it was deemed to be beneficial for inclusion in this assessment. Key information sources are presented in Table 2.1.

Table 2.1. Key information sources

Data Source	Reference
4C Offshore	Anholt Wind Farm Project Vessel Database, (4 C Offshore, 2013):
Rambøll	Anholt Offshore Wind Farm Air Emissions, (Rambøll, 2009).
Danish Environment Agency	Statutory Order number 1284, (Miljøministeriet, 2011)
Energinet.dk	HR3 Technical Project Description, Offshore 2013, v3
UK Department for Transport (DfT)	Calculation of Road Traffic Noise (Department of Transport, 1988)



On board an offshore installation vessel.

3. METHODOLOGY

The detailed design of Horns Rev 3 has not been finalized, therefore a number of assumptions have been made (detailed below) in the calculation of noise associated with the scheme. Estimations in this report are therefore indicative of noise emissions likely to occur. Conservative assumptions have been made where relevant so that where there are uncertainties over the detailed project design. The associated noise emissions approach provides a conservative assessment.

3.1. Study area

The offshore study area included the offshore project site and export cable route to landfall, Figure 3.1.

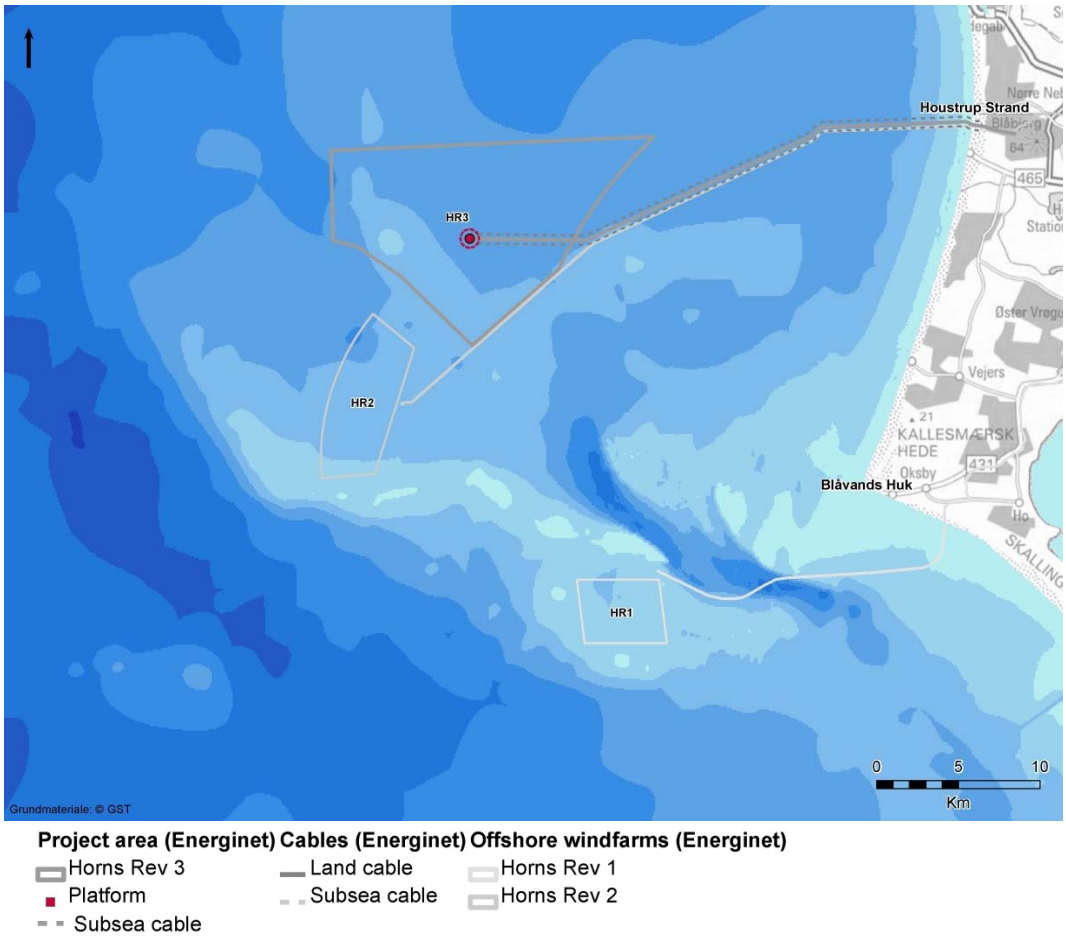


Figure 3.1. Offshore project site for Horns Rev 3 Offshore Wind Farm.

3.2. Characterisation of the existing environment

In order to characterise the existing environment within the study area, assumptions have been made regarding the prevailing baseline noise environment. Measurements of the ambient noise level have not been collected specifically for the Horns Rev 3 project.

Sensitive receptors, in the context of noise and vibration, are typically residential premises but can also include schools, places of worship and noise/vibration sensitive commercial premises.

3.3. Assessment of impacts

3.3.1 Offshore Construction Phase Impacts

Noise emissions from marine vessels associated with construction of Horns Rev 3 were estimated as described below.

Emissions were estimated for two scenarios: 1) for wind turbines supported by monopile foundations, and 2) for wind turbines supported by gravity base foundations (as higher emissions were estimated from vessels installing this type of foundation for Anholt wind farm (Rambøll, 2009)).

An inventory of marine vessels likely to be used for construction and operation of Horns Rev 3 was compiled following best practice guidance in preparing port emission inventories from the United States Environmental Protection Agency (USEPA).

The marine vessel inventory was based on details of marine vessels used during construction of the now fully commissioned Anholt wind farm, (4 C Offshore, 2013). Marine vessels used during the construction and operational phases of Anholt wind farm (which has an installed power of 399.6 MW comprising 111 turbines (3.6 MW each)), with monopile foundations, are considered representative of marine vessels likely to be used for Horns Rev 3. Marine vessels likely to be associated with installation of gravity base foundations were obtained from the Anholt Wind farm emissions assessment report (Rambøll, 2009).

Noise emission rates from marine vessels were obtained using information such as hours of operation, time in service, vessel characteristics, and number, type and horsepower of main and auxiliary engine(s) (obtained from the Anholt Wind Farm Project Vessel Database, (4 C Offshore, 2013)).

Noise emissions estimates are shown in Table Error! No text of specified style in document. 3 and the following assumptions were made:

- Marine vessels used during construction phase of the Anholt wind farm are representative of vessels likely to be used for Horns Rev 3;
- All vessels are assumed to operate for 24 hours in 24 hours;
- Time in service for each vessel was obtained from the Anholt Wind Farm Project vessel database;
- The number and type of marine vessels used for installation of gravity base foundations were obtained from the Anholt wind farm emissions assessment report which included two scenarios for foundation types: concrete base, and gravity base (Rambøll, 2009).
- All vessel main engines were assumed to be operating for 80 % of the time and auxiliary engines for 20 % of the time (during the working day); and

- Monopile or gravity base foundations are likely to be used for Horns Rev 3.

The types of construction vessels will be selected by the nominated contractor; however an overview of the main types of vessels for each task is presented in Table 3.1 and based on the assumption of one turbine base being piled on any one occasion, the piling noise emissions are estimated in Table 3.2.

Table 3.1. Estimated noise sources from marine vessels.

Task	Likely Type of Construction Vessel
Pile Installation	Jack-up rig, floating crane and barge
Gravity Base Installation	Floating crane and barge
Wind Turbines	Jack-up rig
Scour Protection	Construction barge or dedicated barge
Cable Installation	Dedicated cable lay vessel
Offshore Transformer Station	Floating crane and barge
Crew Transfer	Workboat
Assisting vessels	Tugs, MultiCats etc.

Table 3.2. Estimated noise emissions from piling activities.

Task	Estimated Noise Emissions (underwater)
Monopile Foundation (vibro)	160 dB re. 1 µPa Sound Exposure Level (SEL) (Thilsted, et al., 2013)
Gravity Base Installation	129 dB at 5m max SPL (Marmo, et al., 2013)

To optimize the construction programme, it is likely that installation of wind turbines, foundations and cables will be undertaken on the site at the same time, although not necessarily within the same part of the site. Therefore it is likely that around 20-30 vessels (including support craft) may be on site at any time during the construction phase. Work will be carried out 24 hours a day when the conditions are optimal, and can be carried out throughout the year.

During construction (and decommissioning) noise emissions will be generated by marine vessels and helicopters working in the construction, operation and decommissioning phases; however these emissions are not considered to be significant (Energinet, 2014).

A comprehensive Environmental Management System is expected to be implemented prior to construction in consultation with statutory authorities, with a suite of complementary management plans corresponding to different aspects related to the construction activities. The Environmental Management System would form a component part of the construction contract for the development.

Due to the large separation distance (ca.17 km) between the wind farm construction activities and the terrestrial receptors, which includes the installation of 10m monopoles, it is considered appropriate to scope this impact out, as noise emissions are considered to be negligible (Energinet, 2014).

Potential underwater noise impacts on ecological receptors are discussed in other specific technical reports (Orbicon, 2014a; Orbicon, 2014b; Orbicon, 2014c).

3.4. Offshore operational noise

There are two types of noise associated with wind turbines; aerodynamic and mechanical noise.

Aerodynamic noise is broadband in nature, relatively unobtrusive and is strongly influenced by incident conditions, wind speed and turbulence intensity. An operational Sound Power Level is expected in the order of 105 dB(A) to 113 dB(A), depending on the selected turbine type and the wind speed.

Mechanical noise is generated by components inside the turbine nacelle and can be radiated by the shell of the nacelle, blades and the tower structure. Such noise emissions are not considered significant for the present generation of turbines being considered for the Horns Rev 3 Offshore Wind Farm

In accordance with the guidance provided by the Danish Environment Agency (Miljøministeriet, 2011), the operational noise impact from a wind farm should not exceed the following noise limits:

1) Outdoor areas at a maximum of 15 m from residential receptors:
   - 44 dB(A) at wind speed 8 m/s
   - 42 dB(A) at wind speed 6 m/s

2) Outdoor areas in residential or recreational areas:
   - 39 dB(A) at wind speed 8 m/s in residential areas.
   - 37 dB(A) at wind speed 6 m/s in residential areas.

If a turbine has a pure tonal element, a penalty of +5 dB should be applied.

Three turbine layout scenarios have been presented for construction in Horns Rev 3 and it has been determined that Scenario E is deemed to offer the most significant potential for impact to coastal receptors, Figure 3.2. This scenario locates the largest number of turbines on the coastal (easterly) edge of the Horns Rev3 designated area.

At present there is no noise emissions data available for the 10 MW turbines; however it has been agreed to use noise emissions values for the 8 MW turbines. As there will be a reduction in turbines when considering 10 MW turbines compared to the 8 MW turbine scenario, the total sound level are likely be comparable.

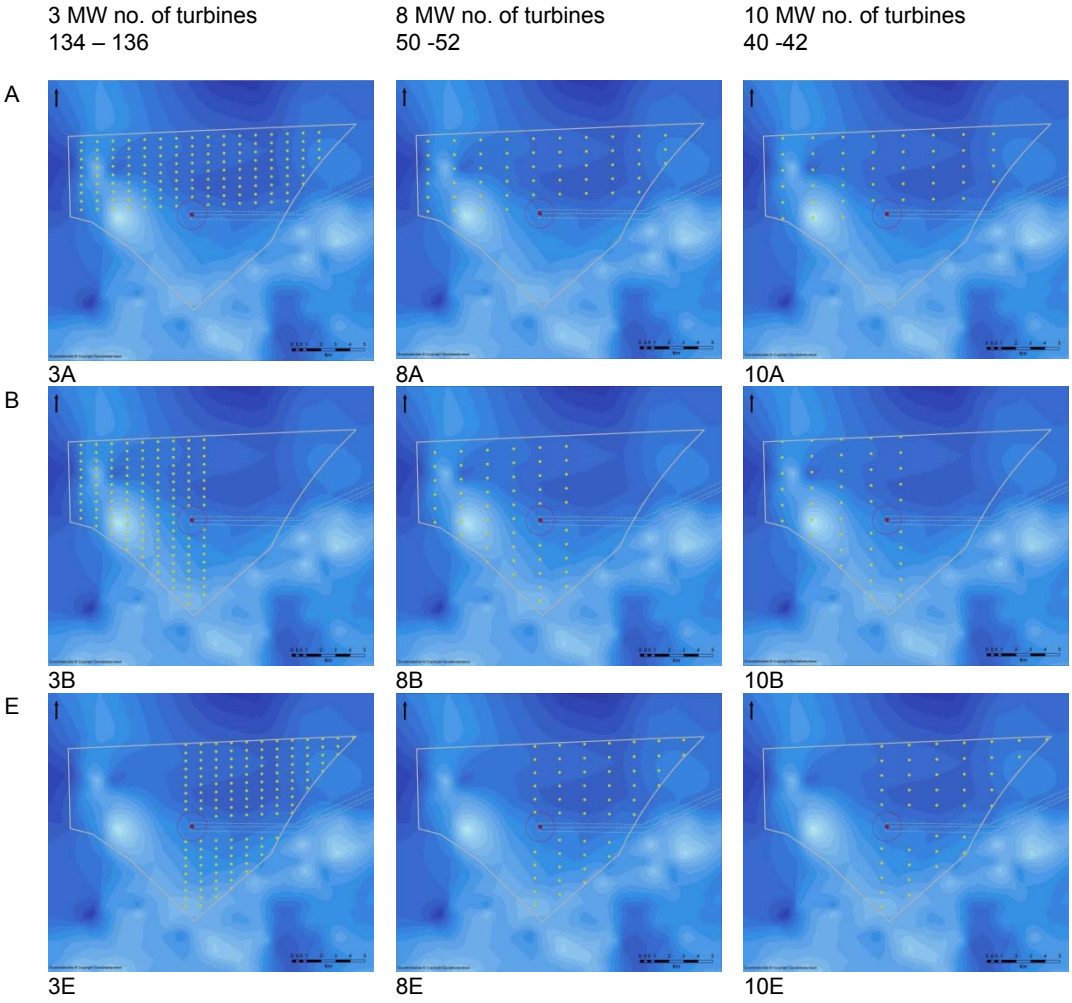


Figure 3.2. Possible park layouts for the Horns Rev 3 Offshore Wind Farm.

The 3 MW, 8 MW and 10 MW turbines have been modelled at 6 m/s and 8 m/s wind speeds, using the following noise source levels:

- Source level 3 MW at 6 m/s LWA re 1pW 105 dB(A)
- Source level 3 MW at 8m/s LWA re 1pW 107 dB(A)
- The height of the source is 81 metres

- Source level 8 MW at 6 m/s: LWA re 1pW 111 dB(A)
- Source level 8 MW at 8 m/s: LWA re 1pW 113 dB(A)
- The height of the source is 107 metres

- Source level 10 MW at 6 m/s: LWA re 1pW 111 dB(A)
- Source level 10 MW at 8 m/s: LWA re 1pW 113 dB(A)
- The height of the source is 107 metres

In order to predict the noise levels from the operation of the turbines, a computer noise modelling study was undertaken. The SoundPLAN software package was used, which is

a commercially available package which implements many national and international acoustic calculation standards, including Nord2000. A 3-dimensional model of the proposed surrounding area was constructed, based on topographical data, ordinance survey mapping and indicative layout plans of the relevant turbine scenarios.

It is also worth noting that the noise modelling provided for the Anholt Offshore Wind Farm has demonstrated that operational noise from 174 turbines operating concurrently would be below 35 dB(A) at approximately 5 km distance from the nearside edge of the wind farm.

Underwater operational noise impact of the offshore wind farm is assessed in a specific report (Orbicon, 2014e).

3.5. Operational noise from the offshore converter station

Operational noise impact of offshore converter stations can be scoped out this EIS due to the large separation distance between the offshore wind farm site and terrestrial receptors. Resultant terrestrial noise levels from the offshore converter station are expected to fall significantly below the Danish Environment Agency suggested limits. The operational noise impact of the offshore converter station is therefore assessed to be negligible.

Underwater operational noise impact of the offshore converter station is not assessed in this report.

3.5.1 Decommissioning phase impacts

The decommissioning activities with the potential to have an impact on noise and vibration would be similar to those occurring during the construction phase, assuming the infrastructure is removed. As such, the potential noise and vibration impacts associated with the decommissioning phase were assessed qualitatively with reference to the potential impacts associated with the construction phase.

3.6. Impact Assessment - methodology

3.6.1 Receptor sensitivity

To identify the significance of any potential noise and vibration impacts the sensitivity of the receptor has been considered based on the criteria provided within Table 3.3.

Table 3.3. Definitions of terms relating to the sensitivity of generic receptors.

Sensitivity	Definition
Very High	Hospitals (e.g. operating theatres or high dependency units), care homes at night
High	Residential accommodation, private gardens, hospital wards, care homes, schools, universities, research facilities, national parks, during the day; and temporary holiday accommodation at all times
Medium	Offices, shops, outdoor amenity areas, long distance footpaths, doctors surgeries, sports facilities and places of worship
Small	Warehouses, light industry, car parks, agricultural land

3.6.2 Overall impact

Following the identification of receptor sensitivity and impact magnitude, it is possible to derive the overall impact following the criteria in Table 3.4 and Table 3.5.

Table 3.4. Degree of impacts for each activity (Without mitigation).

Sensitivity of Area	**Magnitude of noise pressure**		
	High	Medium	Low
Very High	Very high	High	High
High	High	High	Medium
Medium	High	Medium	Low
Low	Medium	Low	Low

Table 3.5. Degree of impacts for each activity (Without mitigation)

Sensitivity of Area	Magnitude of noise pressure		
	High	Medium	Low
Very High	Medium	Medium	Low
High	Medium	Low	Low
Medium	Low	Low	Low
Low	Low	Low	Low

Installation of monopiles at Horns Rev 2

4. EXISTING ENVIRONMENT

4.1. Local noise emission sources

Existing sources of noise in the study area will include existing offshore wind farm turbines, shipping and general sea noise.

4.1.1 Assessment criteria

Noise impacts associated with the construction, operational and decommissioning phases of Horns Rev 3 were assessed following criteria outlined in the Horns Rev 3 report on method for EIA (Orbicon, 2013).

Fishing vessel and wind turbines at Horn Rev 1

5. SOURCES OF IMPACTS

5.1. Main impacts – construction phase

Offshore construction activities such as those described below have the potential to generate noise emissions:

- The installation of 10m monopiles has the potential to impact upon terrestrial receptors. However due to the large separation distance (ca.17 km) between the wind farm construction activities and the terrestrial receptors, it is considered appropriate to scope this impact out, as noise emissions are considered to be negligible (Orbicon, 2014f); and
- Marine construction vessels.

5.2. Main impacts – operational phase

The main offshore operational noise impact will be turbine noise from the wind farm.

Once operational, there will be site traffic associated with maintenance of the offshore wind farm. Marine vessels will be used for cable and turbine maintenance activities.

Noise emissions from road vehicles and marine vessels associated with maintenance activities will be negligible.

5.3. Main impacts – decommissioning phase

Impacts associated with the decommissioning of the cable route, converter stations and offshore infrastructure will be similar to those identified during construction. These include noise emissions from non-road mobile machinery (NRMM) and road traffic during the decommissioning phase.

Cable laying vessel near shore

6. ASSESSMENT OF EFFECTS OFFSHORE

6.1. Offshore Construction Phase Impacts

Noise emissions from marine vessels associated with construction of Horns Rev 3 were estimated.

During construction (and decommissioning) noise emissions will be generated by marine vessels and helicopters; however these emissions are not considered to be significant.

A comprehensive Environmental Management System is expected to be implemented prior to construction in consultation with statutory authorities, with a suite of complementary management plans corresponding to different aspects related to the construction activities. The Environmental Management System would form a component part of the construction contract for the development.

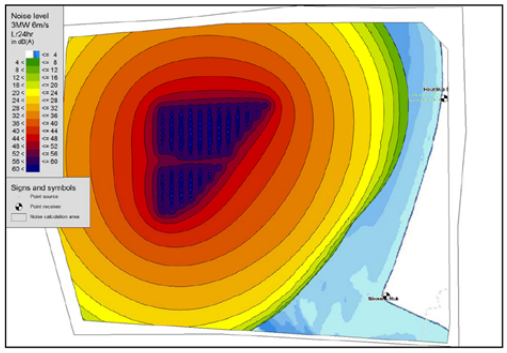
Due to the large separation distance between the wind farm construction activities, including monopiling activities, and the terrestrial coastal receptors it is considered appropriate to scope this impact out, as noise emissions are considered to be negligible

6.2. Offshore Operational Phase Impacts

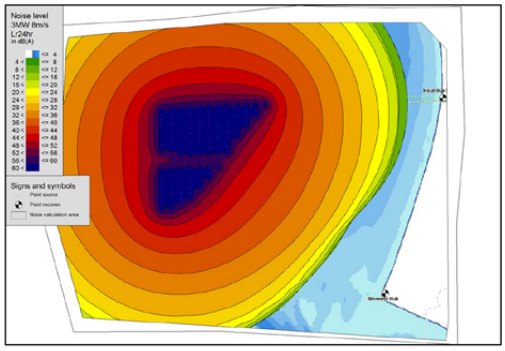
Using the noise emissions data and assessment methodology provided in Section 3.4 and assessment policy/guidance in Section 2.1, predicted coastal receptor levels are shown in the following noise contoured isopleths, Figure 6.1 and summarised in table Table 6.1

Transformer platform and crew boat – Anholt Offshore Wind Farm

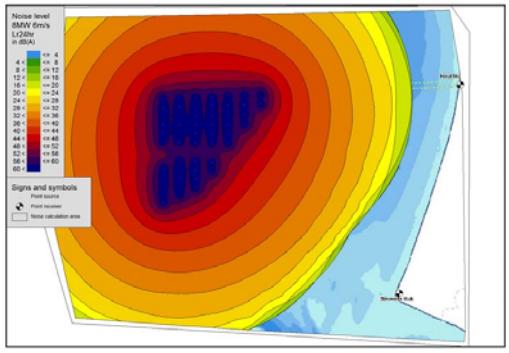
3 MW turbines at 6 m/s



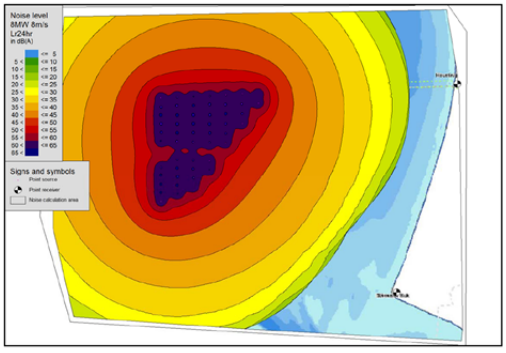
3 MW turbines at 8 m/s



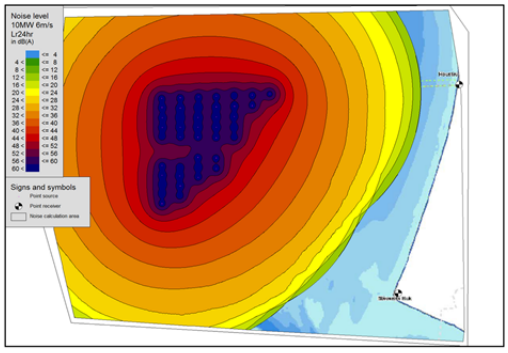
8 MW turbines at 6 m/s



8 MW turbines at 8 m/s



10 MW turbines at 6 m/s



10 MW turbines at 8 m/s

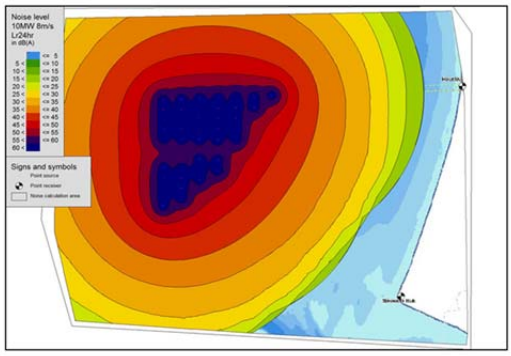


Figure 6.1. Isopleths for predicted coastal receptor levels in turbine scenario E – (worst case).

Table 6.1. Predicted resultant turbine noise levels.

Turbine	Wind Speed	Predicted Noise Impact at Houstrup Strand	Predicted Noise Impact at Blåvands Huk
MW	**m/s**	**dB(A)**	**dB(A)**
3	6	<0	<0
3	8	<0	<0
8	6	<0	<0

Turbine	Wind Speed	Predicted Noise Impact at Houstrup Strand	Predicted Noise Impact at Blåvands Huk
8	8	<0	<0
10	6	<0	<0
10	8	<0	<0

Wind turbines must respect noise limits in accordance with the environmental policy (Miljøministeriet, 2011). The limits are specified as:

For dwellings, summer cottages, etc.:

- 39 dB (wind speeds of 8 m/s) and 37 dB (wind speeds of 6 m/s)

For dwellings in open country:

- 44 dB (wind speeds of 8 m/s) and 42 dB (wind speeds of 6 m/s)

Table 6.1 demonstrates that the predicted noise impact of the operational Horns Rev 3 offshore wind farm is negligible and it is predicted that there will be no audibility at the nearest coastal residential dwellings. The resultant terrestrial noise levels are expected to fall significantly below the Danish Environment Agency suggested limits. The operational noise impact of the offshore wind farm is therefore assessed to be negligible.

6.3. Decommissioning Phase

The decommissioning of the offshore elements of Horn Rev 3, including the cable route and the converter stations will form part of an overall Decommissioning Plan, for which a full EIA would be carried out ahead of any decommissioning works being undertaken.

In relation to the converter stations, the programme for decommissioning would be expected to be similar in duration to the construction phase. The detailed activities and methodology will be determined later within the project lifetime, but is expected to include:

- dismantling and removal of above ground electrical equipment; and
- removal of any building services equipment;

At the time of decommissioning, it will be evaluated whether the buried cable system could be used for another purpose.

7. CUMULATIVE IMPACTS

This section describes the approach to cumulative impact assessment for noise impacts, taking into consideration other plans, projects and activities.

When additional projects within the same region affect the same receptors at the same time, they are said to have cumulative impacts. These effects would occur should the Horns Rev 3 development coincide with other wind farm projects, activities or plans. A project should be included in the cumulative impact assessment if it meets one or more of the following requirements:

- The project and its impacts are within the same geographical area as Horns Rev 3;
- The project affects some of the same or related receptors as Horns Rev 3; and
- The project has permanent impacts during the operational phase that might interfere with impacts arising from Horns Rev 3.

The noise emissions are produced in relation to the construction of Horns Rev 3. Therefore there will be no permanent cumulative effects generated by the project. Temporary cumulative effects have been considered in relation to other relevant construction works relevant to the construction sites of Horns Rev 3. At present no relevant projects or plans are known.

Horns Rev 2 Offshore Wind Farm

8. SUMMARY OF IMPACT ASSESSMENT

This report has assessed the potential noise impacts of offshore elements associated with Horns Rev 3 may have on surrounding noise sensitive receptors.

Table 8.1 provides a summary of the potential impacts of noise arising from the scheme. The main impacts in relation to noise are associated with the construction phase of Horns Rev 3 (including monopole installation) and the operational stage of the converter station. Residual impacts during the construction stage are assessed as negligible. The operational noise impact is assessed as negligible. The impacts during decommissioning will be similar to those during construction and will be subject to a decommissioning plan and associated EIA at the relevant time.

Table 8.1. Summary of predicted impacts on noise emissions as associated with Horns Rev 3.

Description of Impact	Key Mitigation Measures	Residual Impact (Worst Case Scenario)
Construction Phase		
Offshore construction noise	None proposed	Negligible
Off-site construction traffic noise	None proposed	Negligible
Operational Phase		
Offshore Wind Farm	None proposed	Negligible
Offshore Converter Station	None proposed	Negligible
Decommissioning Phase		
Decommissioning	Similar to those identified for construction	As per construction

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