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ENERGY ISLAND BORNHOLM

TECHNICAL REPORT – RADAR, RADIO AND AVIATION

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TECHNICAL REPORT – RADAR, RADIO AND AVIATION

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CONTENTS

Abbreviations

AIS	Automatic Identification System (Automatic Vessel Tracking)
BL	Bestemmelser for Luftfart
DAT	Danish Air Transport
ENS	Danish Energy Agency
DGPS	Differential Global Positioning System
DMI	Denmark´s Meteorological Institute
EASA	European Aviation Safety Agency
EIB	Energy Island Bornholm project
FL	Flight Level
GA	General Aviation
ICAO	International Civil Aviation Organisation
ILS	Instrumental Landing System
MSA	Minimum Sector Altitude
NM	Nautical Mile
OLS	Obstacle Limitation Surfaces
RNAV	Area Navigation
SAR	Search & Rescue
SFS	Danish Maritime Authority (Søfartsstyrelsen)
SMHI	Swedish Meteorological and Hydrological Institute
THR	Threshold
TS	Trafikstyrelsen (Danish Civil Aviation Authority)
VOR	Omnidirectional Radio Range
VTS	Vessel Traffic Service

1. SUMMARY

In this report available information on radar systems and radio chains as well as aviation requirements have been used to conduct a preliminary analysis of potential interference and conflicts of these assets from the Plan for Program Energy Island Bornholm. The scope of the analysis included installations in Denmark, Southern Sweden, and Northern Germany.

1.1 Radars

The conducted analysis included meteorological radars, civil aviation radars and defence surveillance radars. As a result of the analysis and conducted survey the following conclusions have been drawn:

1. Overlap between turbine positions and the lowest elevation scan (0.5 deg.) of DMI´s Rønne weather radar leads to false signals and two 45 deg. azimuthal shadow sectors behind the wind parks. The impact is not expected to require mitigation measures based upon the preliminary analysis. However, detailed analysis will be required based upon turbine design parameters and configuration.
2. There are no significant conflicts with civil aviation radar systems. The closest Danish Airport (Bornholm) does not use radar technology for air traffic control. German and Swedish airport radar systems will not be affected because of their distance to the project area.
3. Overlap between the radar detection volume and the proposed wind park areas leads to moderate negative impact on the three military surveillance radars installed on Bornholm including blockage, mispositioning and "disappearance" of target objects. A separate analysis for this is being prepared by third party according to agreement between Energinet and Danish Defence.

1.2 Radio chains

Following the search criteria of the frequency license database radio chains have been divided in six permission groups, which represent typical radio applications. Most of the installations are not intended to transmit signals to or across the offshore area. For those systems potential interference could be excluded. However, two installations were identified, for which the offshore Baltic Sea is target. The first one is a transmitter and receiver at Aarsballe, which is part of the Danish coastal radio network, used for maritime emergency, fire- and safety communications operated by the Danish Energy Agency. The second is a Differential Global Positioning System (DGPS) at Hammerodde Lighthouse, which transmits differential corrections to the GPS system to achieve greater positioning accuracy.

According to the analysis, these two systems will only experience minor negative effects due to the presence of the turbines.

1.3 Aviation

The flight patterns and procedures at Bornholms Lufthavn have been analysed. No serious conflicts between the planned wind farms and the air traffic to and from Bornholm Airport have been identified.

The risk of a collision between an airplane and a wind turbine is extremely small and acceptable from a regulatory point of view. A distance of 15 kilometers between the wind farms and the airport will be applied and a set of "no-obstacle" surfaces will be introduced around the airport.

2. INTRODUCTION

The energy islands mark the beginning of a new era for the generation of energy from offshore wind, aimed at creating a renewable energy supply for Danish and foreign electricity grids. Operating as renewable power plants at sea, the islands are expected to play a major role in the phasing-out of fossil fuel energy sources in Denmark and Europe. One energy island is planned in the North Sea and one in the Baltic Sea.

After political agreement on the energy islands has been reached, the Danish Energy Agency plays a key role in leading the project that will transform the two energy islands from a vision to reality. The energy island projects are pioneer projects that will necessitate the deployment of existing knowledge into an entirely new context.

The Plan for Programme Energy Island Bornholm ("The plan") sets the framework for the construction of Energy Island Bornholm - one of the first energy islands in the world and a pioneering offshore wind energy hub in the Baltic Sea (see Figure 2-1).

The plan includes offshore planning areas for an offshore wind farm ("OWF") 15 km from Bornholm, and for subsea cables in Danish waters between Bornholm and Zealand as well as between Bornholm and German waters.

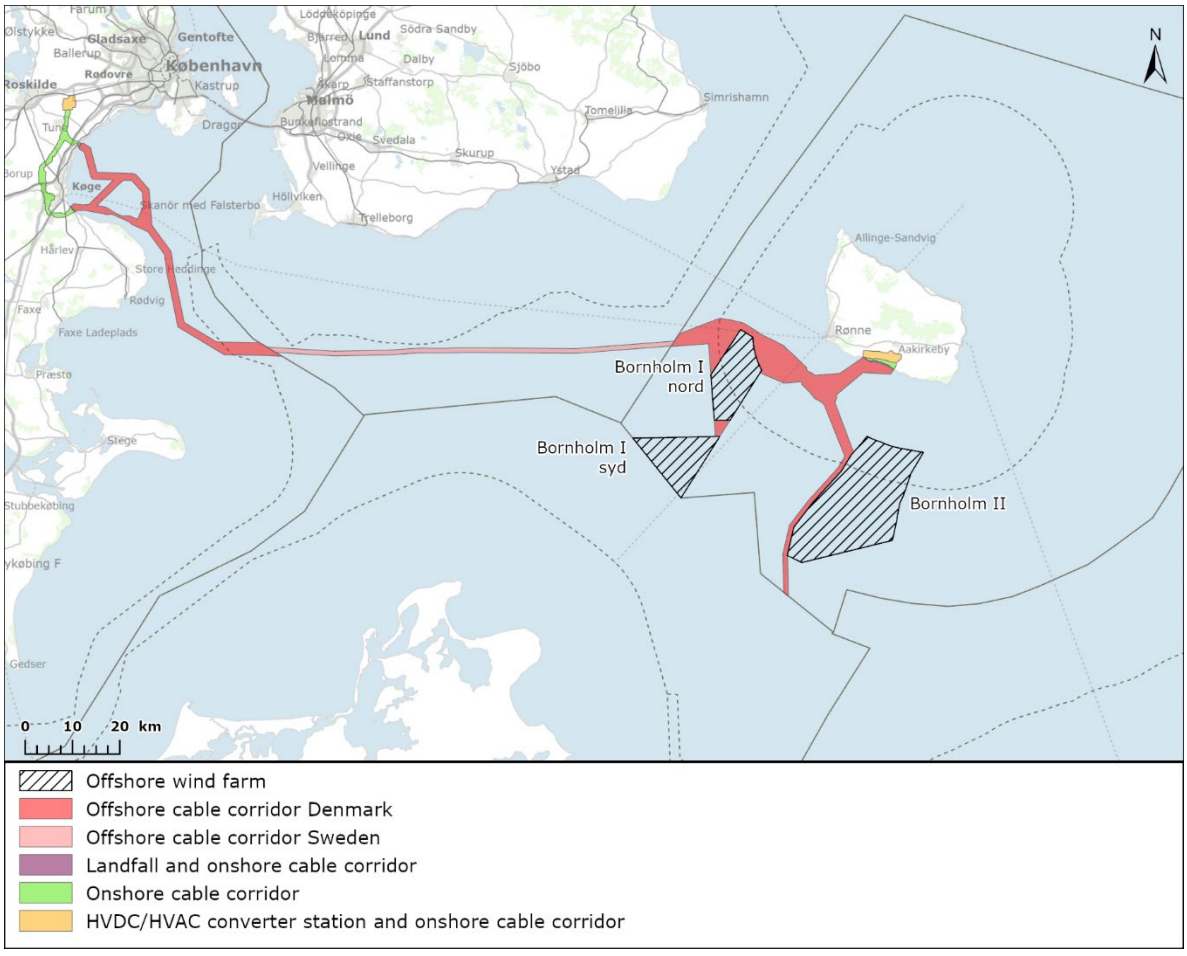

Figure 2-1 Planning areas in the Plan for Programme Energy Island Bornholm.

The before mentioned planning area is divided in to three OWF areas: Bornholm I Syd (118 km2), Bornholm I North (123 km^2) and Bornholm II (410 km^2). The planning areas, as mentioned above, will contain wind turbines with a maximum height of 330 m, maximum 7 transformer platforms, and subsea cables. Combined; these three OWF areas will have an installed production capacity of up to 3,8 GW including overplanting. Additional information regarding the planning area can be found in the draft of the Strategical Environmental Assessment for this project.

This report addresses potential conflicts in relation to radar and radio communications and aviation at Bornholm Airport and hence this, the report is divided into two separate sections:

- Section I: Radar and radio
- Section II: Aviation

Section I: Radar and radio interference

Due to their physical characteristics (tower height, rotating blades) installation of offshore wind turbines may affect propagation of microwave energy and consequently impair functionality of existing systems relying on microwave transmission such as radars, radio and TV signals and radio chain links. Radars may be affected by shadow effects (partial blockade of transmitted energy) as well as backscatter of the transmitted signals (reflection and scattering of energy by the wind turbine). For systems relying on line-of-sight communication (*i.e.*, radio, TV, cell phone, radio chain links) presence of wind turbines between the transmitter and receiver may lead to degradation of the transmission/reception process.

The purpose of this report is to summarize the outcomes of the review of the known existing radars and radio assets within the island of Bornholm that potentially will be impacted by the presence of the planned wind turbines.

3. BASELINE CONDITIONS

3.1 Method for collecting data

For the mapping of radar installations and radio chains in the area around Bornholm, data has been collected from the following three countries adjacent to the project area: Denmark, Sweden and Germany. Data collection consisted of a survey, which targeted potentially affected operators, institutions or owners of radar or radio systems. Table 3-1 gives an overview over the identified entities, which may currently operate assets that may be affected by the proposed wind farm installation. The objective with the survey was to identify potentially affected entities and to gain

technical information on their radar and radio systems to be included in the further evaluation presented in Chapter 4.

Table 3-1 Potential radar and radio chain operators included in the analysis of this report.

Denmark	Sweden	Germany
Civil Owners/Operators		
Danish Maritime Authority (SFS)	Teracom AB	German Maritime Agency (GDWS)
Aviation Control (Naviair)	Luftfartsverket	German Aviation Control (DFS)
Danish Meteorological Institute (DMI)	SMHI	German Meteorological Institute (DWD)
Danish Frequency Register hosted by Danish Energy Agency (ENS)	Post og Telestyrelsen	Bundesnetzagentur
TDC	Hi3G Access AB	Deutsche Telekom
Telia	Telenor Sverige AB / Net4Mobility	Vodafone
3.dk	Telia Sverige AB	E-Plus
Inmarsat SE	Myndigheten för samhällsskydd och beredskap MSB	Telefonica
Agency for Data Provision and Streamlining (SFDE)	Lunds universitet avd för zoologisk ekologi	-
Danish Agency for Business (ERST)	Nordvästra Skånes vatten & avlopp AB	-
-	SAAB AB	-
-	Sjöfartsverket	-
-	Stockholms universitet Meterologiska instituitionen MISU	-
-	Trelleborgs Hamn AB	-
-	VA Syd	-
Military Owners/Operators		
Marinestaben, Royal Danish Navy (contact by client)	Försvarsmakten	Bundeswehr
Flyverstaben, Royal Danish Air Force (contact by client)	Försvarets materielverk FMV	Marine
Forsvarets Ejendomstyrelse (contact by client)	Försvarets radioanstalt FRA	Luftwaffe

In addition, data on potentially affected assets in Denmark have been retrieved from the public frequency license registry (frekvensregistret) hosted by the Danish Energy Agency (ENS). Herein all license holders with registered assets of relevant frequency range on the Island Bornholm have been included in the analysis.

3.2 Radars

Radar is an abbreviation for "**Ra**dio **d**etection **a**nd **r**anging systems" and describes systems that rely on microwave energy to detect distant objects. A typical radar works by emitting electromagnetic energy in a given direction. As the energy propagates through the atmosphere it may interfere with an object (through absorption, refraction or reflection), and a small portion of the energy will be directed back to the radar as an echo. The radar's receiver records the time it takes for the returned energy pulse to travel to the object and back and, on that basis, calculates how far the detected object is from the radar. The amount of the reflected energy may be an indication of object's size. Radar's typically have rotating antennas making it possible to provide coverage of large areas, rather than a single direction. Doppler radars utilize phase information of

the transmitted signals to detect magnitude and direction of the velocity (towards or away from the radar) of moving objects.

The following describes the radar types that could potentially be affected by Energy Island Bornholm.

3.2.1 Meteorological radars

The Danish Meteorological Institute (DMI) has installed 5 radars in Denmark to monitor weather parameters such as wind, clouds and precipitation. The radars are located on terrestrial towers and scan the atmosphere with a maximum range of up to 240 km. The standard operating procedure (scanning strategy) allows for continuous collection of meteorological signals within a range of 120 km (of each radar), and up to a height of 1 km above sea level. The radars are located on Stevns, in Sindal, in Virring, on Rømø and on Bornholm and can be seen in Figure 3-1 /1/. The proposed project area is within range (120 km) of the weather radar on Bornholm and within the periphery of the radar at Stevns.

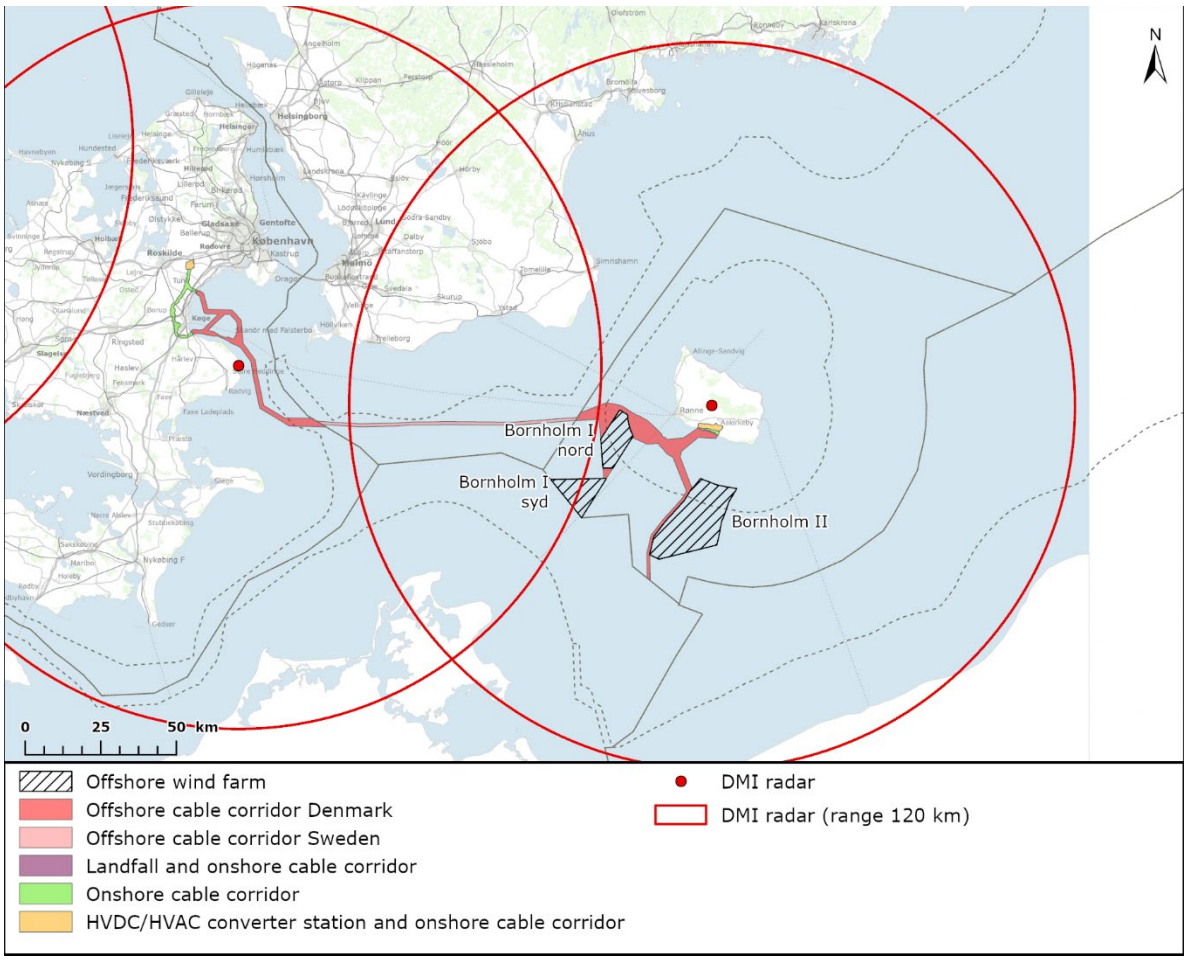

Figure 3-1 The location of the DMI weather radars closest to the project, indicating a range of 120 km.

3.2.2 Civil aviation radars

To monitor air traffic in Denmark, airports use two different types of radar: a primary radar and a secondary radar. A primary radar is a conventional radar that emits a pulse of electromagnetic

waves in the microwave range, as described in the introduction to this section. A primary radar is used for detection (presence) of all objects within its range (e.g., airplanes).

The major Danish airports have primary radars, but in operational practice they also rely on secondary radars (see below) to monitor air traffic. In general, the primary radars have a range of 60 nautical miles, equivalent to 111 km. The secondary radars have a considerably longer range (250 nautical miles) and work by transmitting a signal, which is received by a transponder, which is now fitted on most commercial aircrafts. The transponder sends back the position of the aircraft and a code, which is then used to identify each aircraft.

The airport closest to the project area is Bornholm Airport. However, this airport does not use radar for air traffic control but only procedural approach procedures. This will be further explained in part II of this report.

3.2.3 Defence surveillance radars and vessel traffic service (VTS) radars

In Denmark, the Naval Operational Command (Marinestaben) and the Aerial Operational Command (Flyverstaben) carry out shipping waters surveillance and aircraft registration using radars. The Naval Operational Command´s maritime surveillance is supported by two maritime surveillance centres, located in Frederikshavn and on Bornholm, as well as coastal lookout stations, patrol vessels and Vessel Traffic Service (VTS) at Storebælt and Øresund. Figure 3-2 shows where the Defence has deployed primary maritime surveillance radars in Denmark.
The closest radars to the project plan area are three radars on Bornholm.

At Rytterknægten close to the centre of Bornholm, a Scanter 4000 radar has been installed, which combines over-flight and low-air warning radar that can detect and track ships and low-flying aircraft. A Scanter 4000 radar consists of two rotating antennas and associated radar equipment, which is located in a technical room. This radar is located approximately 25 km northeast of the project area. The location is indicated in Figure 3-2.

Both at Hammeren and Nexø Skyttegård locations the Scanter 2001 type radars have been installed, which are surface warning radars that can detect and follow ships. The Scanter 2001 radar consists of a rotating antenna and associated radar equipment located in a technical room on the ground. The Hammeren radar is located approximately 29 km northeast of Bornholm I North and 43 km north of Bornholm II. The Nexø radar is located approximately 34 km east of Bornholm I North and 17 km north of Bornholm II. The locations can be seen in Figure 3-2.

There are no VTS radars located close to the project area.

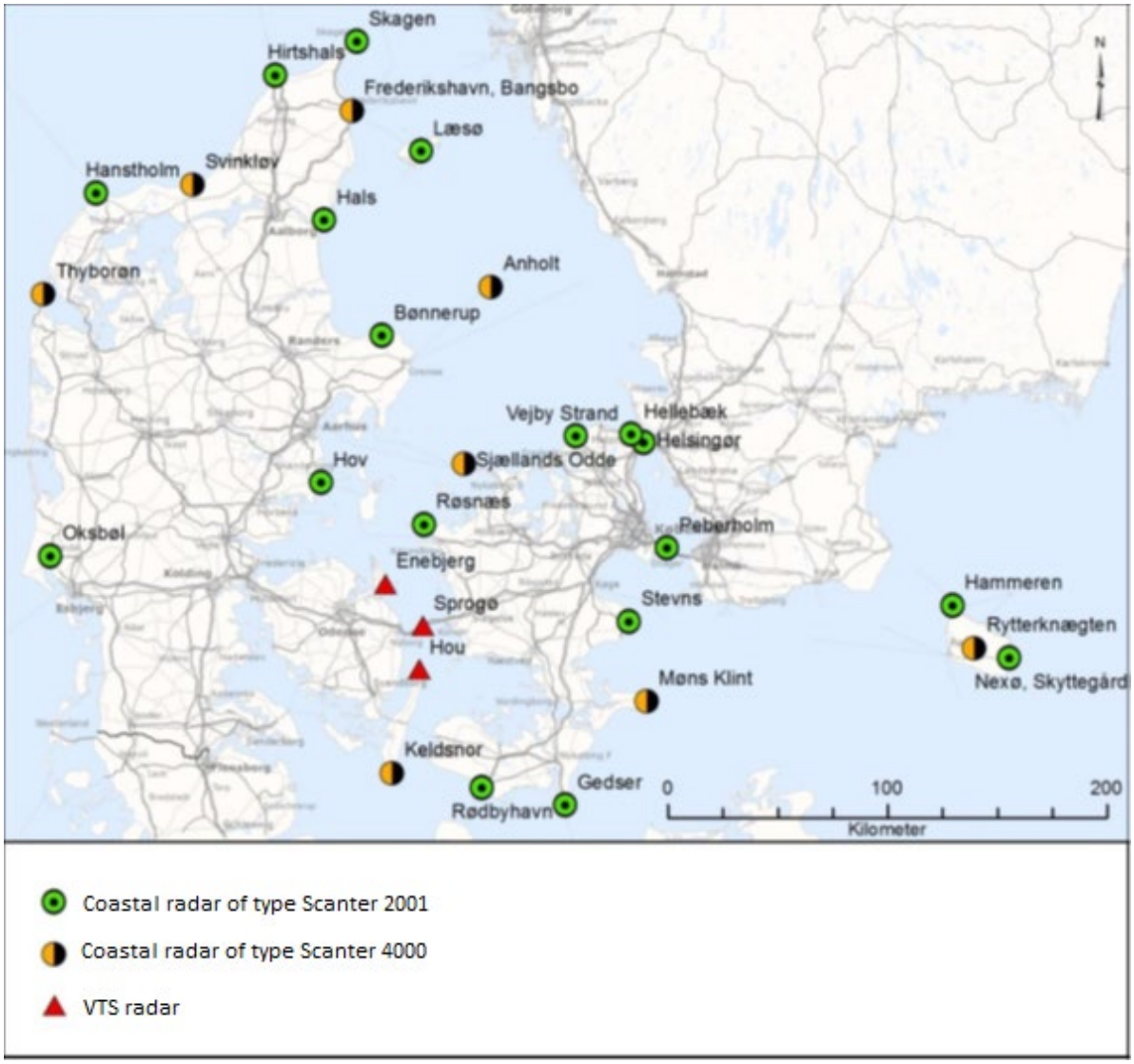

Figure 3-2 Location of radars in Denmark used for maritime surveillance /13/.

3.2.4 Ship-borne (mobile) radar systems

Assessment of navigation including ship radar is presented in a separate report /11/.

3.3 Radio chains

A radio chain is a data transmission link operating between two distant locations. The link is established using very high frequency radio waves. Directional antennas are used, and a radio chain is thus a wireless alternative to a cable connection, for example TV, radio, datalinks, radio-links. Radio chain links rely on relatively unobstructed line-of-sight between the transmitter/ receiver pairs. The proposed wind turbines could potentially affect such communication, if the direct link path was to be obstructed by a wind turbine. Since the location and distance to the wind turbine is one of the primary factors affecting possible interaction, the survey focused on identification of potential radio chain link operators within the island of Bornholm that may communicate with receivers outside of the island (*e.g.*, boats, mainland).

Using the publicly available online database hosted by the Danish Energy Agency (https://frekvensregister.ens.dk/Search/Search.aspx), Ramboll was able to search for those operators that are located within the island of Bornholm, by using the built-in search engine. To

select only those operators with registration with Bornholm, the zip codes within 3700 to 3790 range were specified. The resulting operators were then grouped by their Permission Group and frequency (in Hertz).

The Frequency Register Permission Groups (Tilladelsesgruppe) for the registered operators are summarized in Table 3-2.

Table 3-2 Frequency Register Permission Groups.

Permission Group [English translation[1]]	Tilladelsesgruppe [Danish]
Land Mobil Radio	Landmobil
Low Power	Laveffekt
Maritime/Aviation	Maritim/Luftfart
Mobil Phones	Mobil Telefoni
Radio/TV	Radio/TV
Radio links	Radiokæde, FWA SAT

For each of the Permission Group, operators were further divided by their registered frequency. Frequency grouping was done based on the assumption that frequency may affect the type of potential interference (*e.g.*, high frequency signals may be differently affected than those operating in low frequencies). Table 3-3 below summarizes the number of entries per each Permission Group that was found through the Frequency Register. Entries from each permission group were reviewed individually to identify those potentially affected by the proposed project (see section 4.3).

Table 3-3 Frequency Register Permission Groups Counts.

Permission Group [English translation[1]]	Number of Registered Operators[2]
Land Mobil Radio	46
Low Power	4
Maritime/Aviation	29
Mobil Phones	1
Radio/TV	16
Radio links	135

4. IMPACT ASSESSMENT

4.1 Method for assessment

The evaluation of potential impact of the proposed project on existing systems will be done separately for each radar location and each radio chain and includes the following steps:

1. Screening and selection of affected systems: all known radar systems and radio chains, for which a spatial conflict (radar coverage or line-of-sight for chain links) cannot be excluded based on known parameters (location, coverage) are selected. Main parameters considered in the initial screening are location, frequency, spatial overlap possible (y/n). The screening outcomes will include the responses of the operators (survey).

[1] The Frequency Operator uses Danish as the primary language. English translations are approximate and provided for reference.

[2] Registered Operators within the register may belong to more than one group

2. Spatial overlap of radar range and the Energy Island Bornholm project (EIB): this step contains a three-dimensional estimation of the volume of interference between the radar field of view and the proposed project. Since the design and configuration of the offshore structures (*e.g.*, number, location and type of individual wind turbines) has not been finalized, the estimation will be based on the scenarios provided by the client and, where necessary, on generalized assumptions of standard configurations and radar operating conditions.
3. Spatial overlap between the line-of-sight of radio chain links transmitter pairs in relation to EIB.
4. Nature of interference, e.g., shadow, clutter, blocking: this step contains a prediction and characterization of the expected impact on the radar and radio systems but does not quantify those effects.
5. Significance of interference: the overall significance of a potential impact is assessed using the criteria defined in Table 4-1.
6. Cumulative effects: the identified interferences will be assessed in relation to existing and planned offshore infrastructure projects.

Table 4-1 Criteria for overall significance of impacts.

Overall significance of interference	
Neutral/ no impact	No impact compared to status quo. Radar field of view/radio link does not include the proposed limits of the project.
Minor negative impact	Overlap exists and may lead to marginal or minor effects on the system. The system's ability to perform its functions is not significantly compromised.
Moderate negative impact	Overlap exists and may lead to potential deterioration of system's performance.
Significant negative impact	Significant overlap may lead to loss of system's ability to perform its function. Potential damage to the radar/radio system should be considered. Evaluation of mitigation strategies may be required.
Positive impact	There are positive impacts or benefits associated with installation of the proposed project.

4.2 Potential impact on radar systems

4.2.1 Meteorological radars

4.2.1.1 Denmark

As shown in section 4.2.1 the closest DMI weather radar to the project zone is located at Rytterknægten (Aakirkeby) on Bornholm. To monitor surface precipitation, the radar scans the atmosphere at elevations ranging from 0.5° – 15° with one-degree vertical increments and completes a full volumetric scan approximately every 5 minutes. With a distance of approximately 25 km from the planned offshore wind farm, an overlap between radar coverage and the wind turbines is expected. The approximate beam geometry assuming 3 dB beamwidth is shown in Figure 4-1. The bottom of the lowest elevation scan of 0.5°, which is used for monitoring precipitation at low elevations, has an estimated height of 208 m at 25 km distance /3//9/. This means that any object higher than 208 m will protrude into the lowest radar beam (3 dB beamwidth). The centre and top and of the lowest radar beam have heights of 425 m and 644 m respectively at 25 km distance. This means that the maximum proposed design height of the turbines (330 m) may result in disturbance of the lower beam section well below the beam centre of the lowest elevation scan. The type of interference of the radar signal with wind turbines may include reflections of the energy towards the radar resulting in non-precipitation targets (location

of the turbine visible on weather radar products would be considered clutter). Additionally, scattering of the energy off the wind turbine may result in partial blockage of the propagating beam, resulting in inaccurate estimation of precipitation targets in sectors past the wind park (shadow effects). Behind each of the two wind park fields, the shadow effects may be present within an azimuthal sector of approximately 45°. Rotating blades of the wind turbine will result in non-zero Doppler signals, which minimizes applicability of clutter filters typically used to eliminate stationary (non-precipitation targets). Weather radars use classification algorithms for example to classify rain, hail, snow or false echoes. These algorithms make use of the differences between vertical and horizontal polarization from the received radio waves (dual polarization). Because of the physical characteristics of turbines (large vertical structure with rotating blades) it is expected that deterioration of dual polarization signatures in the "shadow" sectors behind the turbines will affect the quality of classification algorithms.

The EUMETNET OPERA (Operational Program on the Exchange of weather Radar Information) guidelines to minimize the impact of wind turbines on C band weather radars in northern Europe recommends a minimum distance of 20 km between weather radars and wind turbines /9//10/. Since the plan area is located outside of this recommended distance and the degradation of radar returns only affects the lower part of the lowest scan position well underneath the centre line, the impact is rated as "moderate negative" (see Table 4-1).

A detailed analyses may be necessary during subsequent project phase to optimize configuration of the proposed wind farm to minimize negative effects of the wind farms on radar operations.

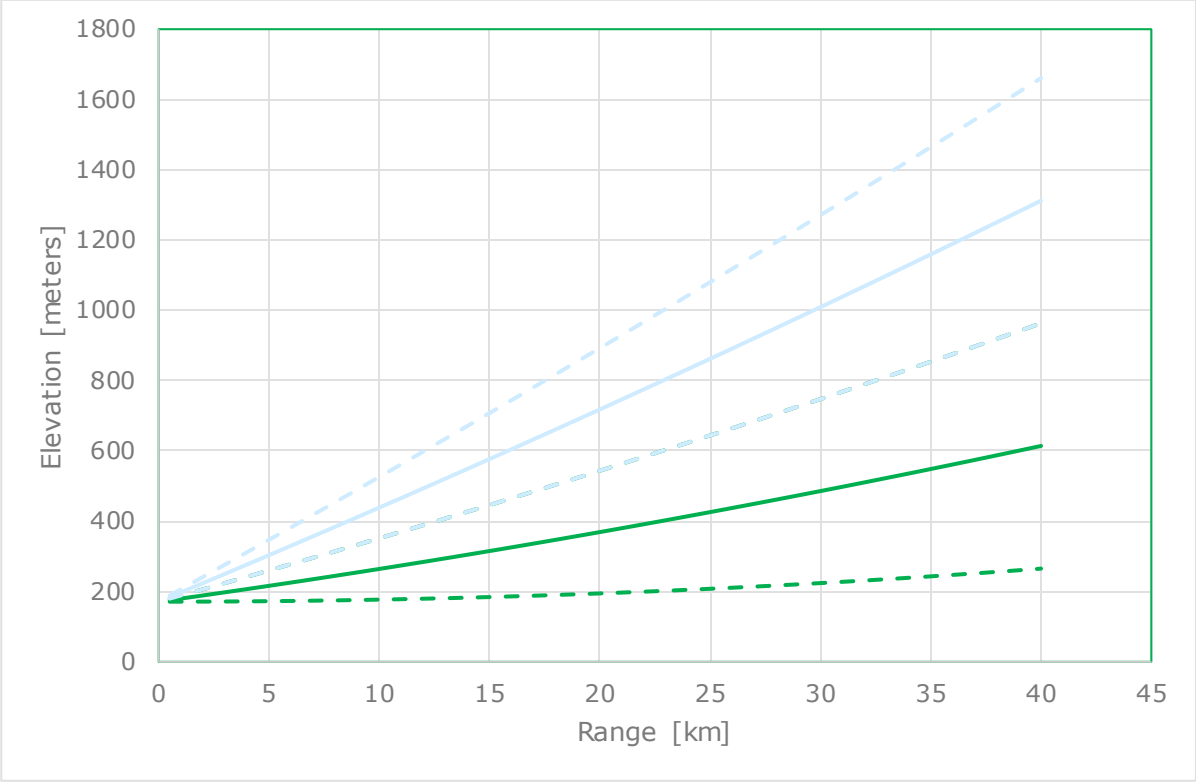

Figure 4-1 Principal beam geometry of the Bornholm weather radar. Green: lowest elevation scan of 0.5°, light blue: elevation scan of 1.5°. Solid lines indicate beam centre, dashed lines indicate 3dB beamwidth.

4.2.1.2 Germany

The closest German weather radar is located near Rostock approx. 150 km away from the southwestern part of the planned wind park fields. Because of the distance, interference can be excluded. This has also been confirmed by the German Weather Service (DWD), who was part of the conducted survey /5/.

4.2.1.3 Sweden

The closest Swedish weather radars are located near Karlskrona and Ängelholm approx. 145 and 155 km away from the northern corner of Bornholm I. Because of the distance, interference can be excluded. The Swedish Meteorological and Hydrological Institute (SMHI) participating in the survey, confirmed this evaluation. However, SMHI stressed, that any active radio link established in connection with the proposed turbines would need a separate evaluation of interference with the Swedish weather radars /11/.

4.2.1.4 Poland

The closest Polish weather radar is located near Swidwin around 120 km away from the southernmost corner of Bornholm II. At this distance a typical weather radar beam (bottom part of the 3-db beam width) is at approximately 1km above ground/sea level, and no interaction with a 300+ meter wind turbines is expected.

4.2.2 Civil aviation radars

4.2.2.1 Denmark

Bornholm's Lufthavn does not use primary or secondary radar for air traffic control. Consequently, there will be no impact or conflict related to civil aviation radars.

The closest Danish airport offering radar service for air traffic control is Copenhagen Airport at approx. 120 km distance. Because of the distance, interference can be excluded.

4.2.2.2 Germany

The closest relevant airport in Germany is Ostseeflughafen Stralsund-Barth, a regional airport located 20 km west of Stralsund. The distance from there to the plan area is 105 km (Bornholm I) and 122 km (Bornholm II). Because of the distance, interference can be excluded.

4.2.2.3 Sweden

The closest relevant airports in southern Sweden are Kristiansand and Malmö. The distance from there to the planning area is 75/80 km (Bornholm I) and 113/122 km (Bornholm II). Because of the distance, interference can be excluded.

4.2.2.4 Poland

The closest relevant airports of northern Poland are Szczecin-Goleniow (122 km), Darlowo military airbase (105 km), the Airport of the 44th Naval Aviation Base of the Polish Navy at Siemirowice (190 km) and Gdansk Airport (250 km). Because of the distances from the proposed project, interferences can be excluded.

4.2.3 Defence surveillance radars and VTS systems

A separate analysis for defence surveillance radars will be prepared by third party according to agreement between Energinet and Danish Defence.
There are no VTS radars in relevant distance to the planning area (se Figure 3-2)

4.2.4 Ship-borne (mobile) radar systems

Impact on navigation is dealt with in a separate report /11/.

4.3 Potential impact on radio chains

As described above in section 3.3 information on radio systems has been retrieved from the Danish public frequency register and relevant entries have been analysed for potential conflicts. The results of this analysis are presented in the following. In addition, relevant results of the surveys in Germany and Sweden are included as far as they concern radio chains.

4.3.1 Land mobile radio

Land Mobile Radio (LMR) system are typically "push-to-talk" two-way communication system between two receivers. Those can be hand-held, vehicle mounted or on a fixed base antenna and are typically used by public safety and for private communication. LMRs typically operate in Low (30-50 MHz) and High (150-172 MHz) VHF Bands as well as UHF Band (450-470 MHz). Due to their low power and earth's curvature, the typical useful range is expected to be between 5 and 30 kilometers (depending on local terrain, transmit power, antenna height and line-of-sight obstructions). For each of the 46 registered entries, the transmitted power and absolute elevation (ground + antenna height) were reviewed to assess if expected signal travel distance may interfere with the proposed Wind Farm. The calculations assumed standard earth's curvature, for which the distance of approximately 25 km would be achieved with antenna elevated at minimum 50 meters above ground.

One single entry with ID C043070-2 (see also appendix 1) is located near Rønne with closest distance to Bornholm I of approx. 19 km. The operator of this installations (Bofa I/S) states, that the antenna is only used for radio communication on the island /1/. It is therefore not relevant.

Equally for the remaining entries, it has been determined that the LMR systems registered on Bornholm would not be considerably affected by the Wind Farm infrastructure proposed to be >15 km from the island.

The impact is rated as "minor negative" impact. Mitigation measures are not required.

4.3.2 Low power

Similarly, the Low Power radio systems registered in the database (four entries between 0.075 and 5 Watts) are not anticipated to be considerably affected by the proposed project, due to their limited operational range estimated based on provided antenna height (max. 15 meters).

The impact is rated as "neutral/ no effect".

4.3.3 Maritime/Aviation

Among the 29 entries in the Maritime/Aviation group, the following four are associated with either significant antenna height or transmit power (see entries in Appendix I):

1. Entry LAN1047-19, operator Danish Energy Agency (Energistyrelsen)

   The station in Aarsballe is part of the Danish coastal radio network, which is used for maritime emergency, fire- and safety communications. The network is nationwide and owned by the Danish Energy Agency. It allows vessels at any location to communicate with the central listening station "Lyngby radio", in this case via the station on Bornholm. The station operates on four channels transmitting around 156 MHz (which is the VHF radio range) and two receivers operating around 160 MHz.

Interference with wind turbines is expected to have a minor effect to the quality of the radio system. First, the antenna has an omnidirectional transmission with a broad coverage, which means that signal transmission is not depending on a single line-of-sight connection. Moreover, propagation characteristics of VHF radio waves allow reflections at turbines, and by this they can travel through the wind park, where they can be received by ships.

The impact on the radio system is therefore rated as "minor negative impact". It is not expected that mitigation measures are required. However, technically, repeaters mounted at the turbines would be able to mitigate the effect.

The Danish Energy Agency, which was part of the survey, has confirmed this assessment /6/.

2. Entry LAN0499-18, operator Danish Defence (Forsvaret)
   It was agreed between Energinet and the Danish Defence that a separate report will be prepared by third party holding the necessary security clearance. This work is done in parallel to this report

3. Entry LAN1061-1, operator GAZ System S.A.

   The asset belongs to the vessel monitoring system provided by GateHouse for the owner and operator of the Baltic Pipe gas pipeline GAZ System S.A. The system is used for automatic vessel tracking (AIS) in the ongoing construction phase of the pipeline. The pipeline is expected to commence operation in October 2022. In principle, the accuracy of the system can experience some degradation when vessels pass by behind turbines (see analysis in the following section right below). However, overlap with construction activities of the Energy Island project and thus any impact can be excluded. GAS Systems S.A., who was part of the survey, states that they do not anticipate a risk for their system /7/.

4. Entry H030176-1, operator Danish Meteorological Institute (DMI). See section 4.2.1.

In addition, the Danish Maritime Agency (Søfartsstyrelsen) operates a Differential Global Positioning System (DGPS) at Hammerodde Lighthouse on Bornholm, which is not registered in the public register. The DGPS station transmits differential corrections to the GPS system in order to achieve greater positioning accuracy, and at the same time the system is able to alert users in the event of GPS system errors. The DGPS station is part of the navigation system in the area and, together with the other markings, helps to ensure the safety of navigation.

The system ´s frequency is 289.5 kHz equivalent to a wavelength of 1035.5 meter. This is several times more than any measurable part of a wind turbine, so the reflective effects at the distance of 27 km + are expected to be negligible.

A DGPS system typically relies on multipath measurements at a specific channel between the receiver and rover receiver (mobile, distant, in this case ships). So, this system operates like a radio (reflections back are not important and not expected as mentioned above).

More important for proper operation is line-of-sight between the antenna and a rover receiver (ships). The 1st Fresnel Zone diameter (2*r in Figure 4-2) at 30 km distance is about 200 meters

wide. The rule of thumb is that the 1st Fresnel zone should be at minimum 60% clear of obstacles (ideally 80%).

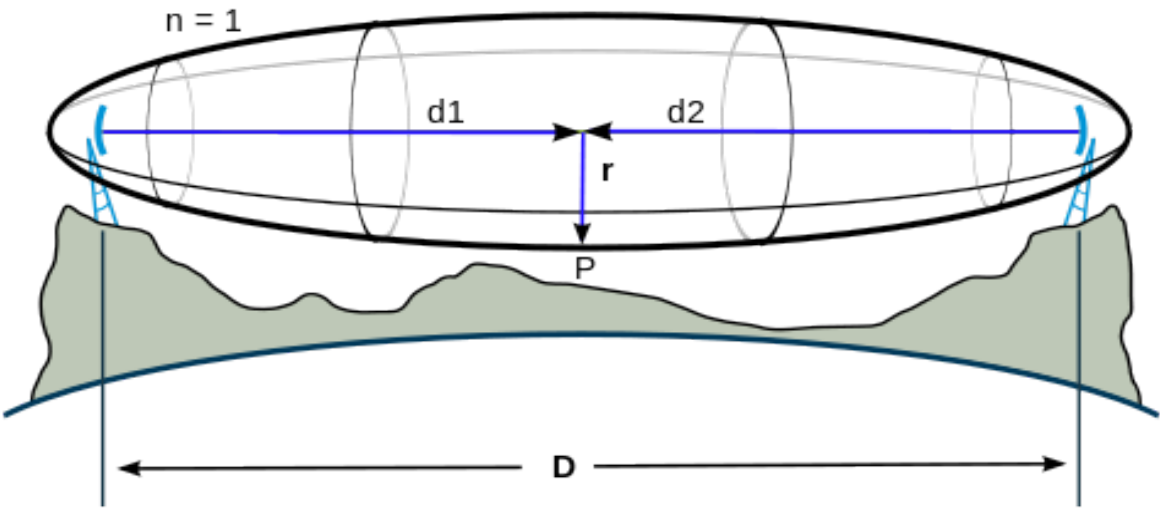

Figure 4-2 Fresnel zone around the centre of a line-of-sight radio connection.

It is possible that when a vessel is traveling very closely to a wind turbine and for a brief moment the line of sight between two receivers is obstructed, some signal degradation may be observed. The effect of this would be that the GPS position of such ship would not be timely corrected with the DGPS system for a short moment (the accuracy of the GPS position is ~10 meters, and about 0.1 meters for DGPS).

The impact is rated as "minor negative" impact. It is not anticipated that mitigation measures are necessary. However, technically, additional transmitting antennas (repeaters) mounted at the turbines would be able to mitigate the effect. A detailed analysis will be necessary based upon design parameters and configuration of the turbines.

4.3.4 Mobile phones

Entries in the frequency register

The Mobile Phone group contains a single entry in the database (H1011150-7, see Appendix I), which is operated by Inmarsat SE, a provider for satellite cell phone services. The character of the system has been assumed to be provided for the residents of the island and the proposed project should not have a significant effect on the operations of the system. A request to Inmarsat SE remained unanswered.

Other operators

As due diligence the survey included Danish, Swedish and German telecommunication operators. A list of the operators is given in attachment 2. From the restricted number of answers received (see also section 9) none of the operators expressed concerns regarding their systems. The Danish operator TDC pointed out that interference shall be considered and evaluated in case active transmitters are installed in connection with construction and/or operation of the turbines.

The impact is rated as "neutral/ no effect".

4.3.5 Radio/TV

Over all 16 entries have been found in the public frequency registry, of which six belong to the Danish State Television/radio (DR), nine to Bauer Media A/S and one to Radio FM4 A/S. DR states that the organisation holds two further licenses with nine transmitter stations for DAB radio and antenna TV. These licenses cannot be retrieved from the public register. Radio and TV signal frequencies are assumed to serve the area of Bornholm, and thus negative impacts derived from offshore installations are not expected. Being part of the survey, DR has confirmed, that it is not expected that the quality of coverage for their transmitters on Bornholm will be affected by offshore structures /4/.

The impact is rated as "neutral/ no effect".

4.3.6 Radio links

The database provides information for some of the registered radio links (point-to-point communication). This information was mapped as shown below. Based on the visual assessment of the registered links with this information, all link chains have internal (within the island) points of communication (see Figure 4-3), so, the proposed project plan, being planned for offshore installation should not affect the functionality of the existing links.

The impact is rated as "neutral/ no effect".

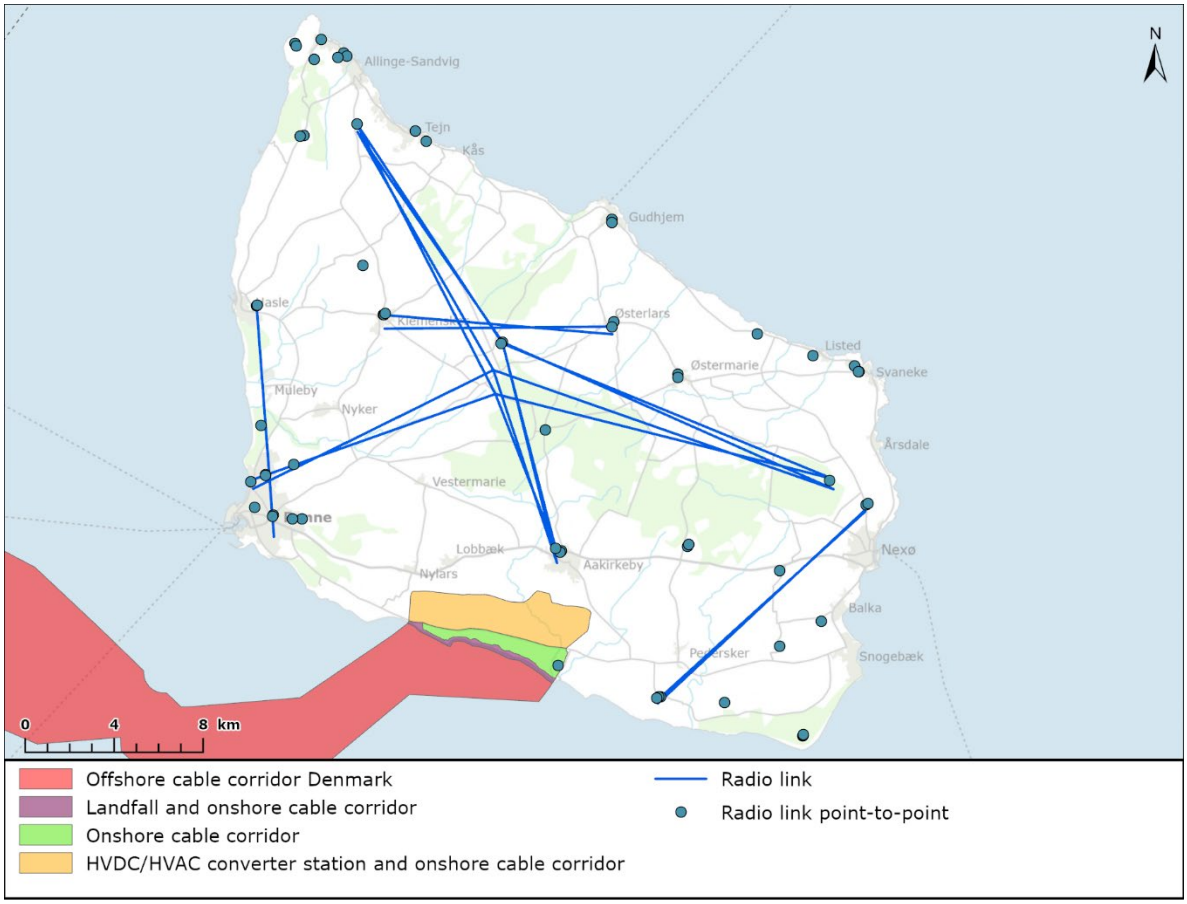

Figure 4-3 Radio links on Bornholm extracted from the public frequency registry hosted by the Danish Energy Agency.

4.3.7 Radio chains Sweden

Land mobile radio and low power

It is not anticipated at such assets operated in Sweden would experience interference with the planned turbines.

Maritime/Aviation

Maritime radio systems can potentially be affected. However, the Swedish Maritime Agency (Sjöfartsverket) expresses that they do not operate systems that can be affected by the planned wind parks. Because of the large distance to the next airports in Sweden, interference with civil aviation can be excluded (see section 4.2.2)

Mobile phones

In the survey the four relevant telecommunication companies have expressed that they do not operate systems that can be affected by the planned wind parks

Radio/TV

The location of the proposed wind parks is not suitable to interfere with Swedish radio/TV transmitters.

Radio links

No indication of the existence of radar chains establishing connections between Sweden and Bornholm has been found. The location of the proposed turbines, however, would not be able to interfere with such connections, if they exist. Because of the distance between Sweden and Germany, radio chains across the Baltic Sea are unlikely.

4.3.8 Radio chains Germany

Land mobile radio and low power

It is anticipated at such assets operated in Germany would not experience interference with the planned turbines.

Maritime/Aviation

Maritime radio systems can potentially be affected. However, the German Maritime Agency (GDWS) expresses that they do not operate systems that can be affected by the planned wind parks. Because of the large distance to the next airports in Germany, interference with civil aviation can be excluded (see section 4.2.2)

Mobile phones

In the survey the four relevant telecommunication companies have been included (Telekom, Vodafone, Telefonica and E-Plus). Only Telekom answered the request stating that they do not have operations in Denmark.

Radio/TV

The location of the proposed wind parks is not suitable to interfere with German radio/TV transmitters.

Radio links

No indication of the existence of radar chains establishing connections between Germany and Bornholm has been found. Because of the distance between Germany and Sweden, radio chains across the Baltic Sea are unlikely.

4.3.9 Radio chains Poland

Land mobile radio and low power

It is not anticipated that such assets operated in Poland would experience interference with the planned wind turbines. The closest distance between the Polish coast and the proposed project area is approximately 68 km. Due to earth's curvature effect, a horizontal radio signal emitted from the polish coast would be approximately 450 m above sea level at the Energy Island area

Maritime/Aviation

Maritime radio systems can potentially be affected. However, it is unlikely that Polish Maritime Agency is operating systems in the Danish EEZ. Because of the large distance to the airports in Poland, interference with civil aviation is not expected (see section 4.2.2)

Mobile phones

The location of the proposed wind parks is not suitable to interfere with Polish mobile phone operations.

Radio/TV

The location of the proposed wind parks is not suitable to interfere with Polish radio/TV transmitters.

Radio links

No indication of the existence of radar chains establishing connections between Poland and Bornholm has been found. Because of the distance between Sweden and Poland, radio chains across the Baltic Sea are unlikely.

4.4 Cumulative impacts

In relation to interference with radar and radio systems cumulative effects are mostly expected with further development of wind energy. Any turbine, which is added within the range of operation of these systems means an additional object of interference with the potential to increase the deterioration of signals transmission and reception. Following the results of the above evaluation this would be the case for the weather radar of DMI and the marine surveillance radars of the Danish defence. Cumulative impacts would be expected both from terrestrial turbines on Bornholm and marine turbines within the radar ranges. Figure 4-4 gives an overview of the existing and proposed wind energy developments in relevant distance to the Energy Island project.

For the DMI's Rønne weather radar it is approximated that the lowest elevation scan is done at 0.5 deg. (above horizon). For this scan the wingtips of the largest turbines (330 m) can interfere with the radar beam up to approx. 50 km as indicated with the red circle in Figure 4-4. It follows from Figure 4-4 that only the eastern part of the Skåne/Triton development area has the potential to protrude into the radar beam. However, since the actual scanning angle is 0.5 ° (see section 4.2.1), none or only minimal interference is expected within the lowest beam. It is concluded that the Energy Island Bornholm is not expected to add to a cumulative impact when considering the other proposed wind farm development projects in the area.

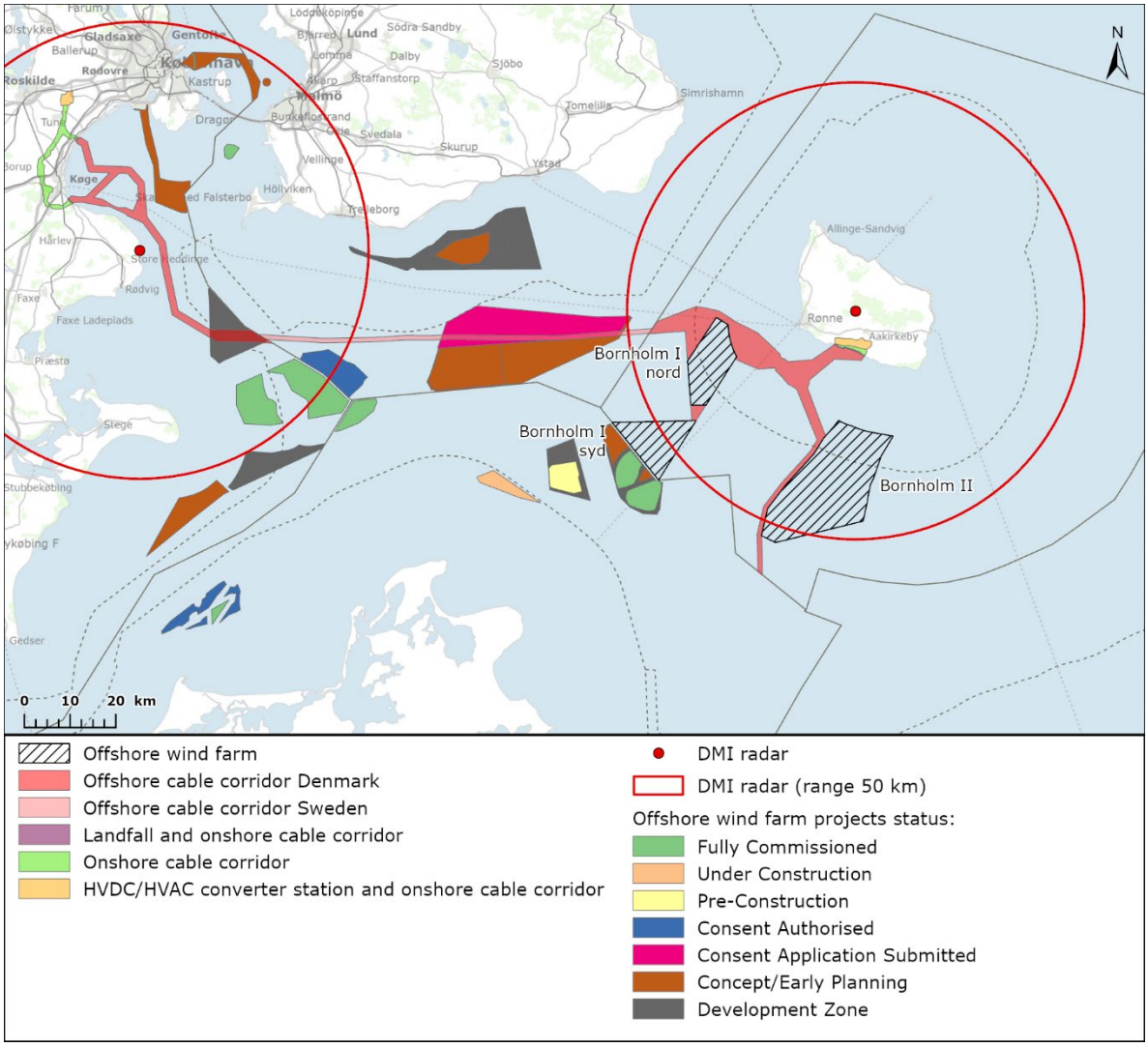

Figure 4-4 Existing and planned offshore wind parks in the Baltic Sea. Red circle: 50 km radius from DMI weather radar.

4.5 Mitigation and compensation measures

4.5.1 Radar systems

As described in Chapter 5, based on the review of available information, the DMI's Rønne weather radar has been identified as being potentially affected by the proposed project. The preliminary analysis of the Rønne radar with respect to the proposed project indicates that only a portion of the lowest (0.5 deg.) elevation scan may be affected by the turbines and it is not anticipated that implementation of mitigation measures will be necessary. However, it will be necessary to check, if final design parameters differ significantly from the generic design parameters used for this analysis in order to evaluate if a new analysis is required (e.g. different turbine dimensions).

If further analysis reveals that the interference of the proposed project with the Rønne radar is non-negligible, the following technical mitigation measures are available:

- Signal processing techniques (clutter filtering, attenuation correction, Doppler signature processing)
- Radar upgrades (antenna height, scanning patterns)

- Infill radars (installation of additional radar to fill gaps in the coverage resulting from installation of the wind park)

With respect to the defence surveillance radars mitigation measures would be either the installation of gap-fillers or the replacement /improvement of the radar system as discussed above for the weather radar. A separate analysis for this is being prepared by third party according to agreement between Energinet and Danish Defence.

4.5.2 Radio chain links

It follows from the analysis in chapter 4.3, that significant interference is not expected for existing radio chain links and thus mitigation measures are not anticipated. However, unforeseen effects, if observed, could be mitigated by repeaters installed at strategic positions within the wind parks, or by modifications to the existing system configuration (e.g., raised antenna, re-pointing).

4.6 Post construction impact evaluation

An evaluation of the impact is suggested to be conducted in the first phase of operation for those assets, for which interference has been predicted (DMI, Military Surveillance Radar). The objective of this exercise is to verify the predicted extent of interference and to provide a basis for eventual mitigation measures. The evaluation will have to be arranged in cooperation with the respective operators.

4.7 Technical deficiencies and/or lack of knowledge

Even though it was considered unlikely that telecommunication companies would be affected in the offshore area, they were included in the survey as due diligence. However, only limited information could be obtained from these companies. As a result, no information or statement could be retrieved from Telia, 3.dk and Inmarsat SE in Denmark as well as Vodafone, Telefonica and E-Plus in Germany. The lack of information from these companies is not considered crucial for the conclusions in this report. No information from Polish telecommunication companies has been retrieved. However, similarly, it is unlikely that they are affected.

5. CONCLUSION

5.1 Radars

In this report radar systems have been identified, for which interference between the radar range and the proposed wind parks may occur. The conducted analysis included meteorological radars and defence surveillance radars. As a result of the analysis and conducted survey the following conclusion have been drawn:

- Overlap between the lowest elevation scan (0.5 deg.) of DMI´s Rønne weather radar and the proposed wind parks leads to a moderate negative impact by creating false signals and two 45 deg. azimuthal shadow sectors behind the wind parks. The impact is not expected to require mitigation measures based upon the preliminary analysis. turbines and it is not anticipated that implementation of mitigation measures will be necessary. However, it will be necessary to check, if final design parameters differ significantly from the generic design parameters used for this analysis in order to evaluate if a new analysis is required (e.g. different turbine height).
- There are no significant conflicts with civil aviation radar systems. Bornholm Airport does not use radar for aviation control and management. Other Danish airports are not affected because of their distance to the plan area Equally, German and Swedish airport radar systems will not be affected because of their distance.

- A separate analysis for this is being prepared by third party according to agreement between Energinet and Danish Defence.

5.2 Radio chains

Based on the review of available information significant interference is not expected for existing radio chain links.

Section II: Aviation

Figure 5-1 Visionary illustration of air traffic near off-shore turbines at Bornholms Lufthavn (not to scale).

It is assumed that the wind farm will be located about 15 km from the coastline with a maximum height of 330 meters for the turbines. The final location and dimensions have not yet been politically approved. The location of the wind farm is quite close to Bornholm and to Bornholms Lufthavn.

The purpose of this analysis is to clarify if there will be any conflicts between the planned offshore wind farm and the operation of aircraft to and from Bornholms Lufthavn. For identification of potential conflicts a risk analysis is carried out and proposals of possible mitigating actions to reduce or eliminate the risks and conflicts are presented.

6. BASELINE CONDITIONS

Bornholms Lufthavn is Denmark´s only state-owned airport administered by Trafikstyrelsen,Danish Aviation Authority and operated by a local management team. The airport is located in the southwest corner of Bornholm with the coordinates

Latitude: 55° 03' 28.80" N
Longitude: 14° 45' 20.39" E

south of Rønne town and close to the sea (see Figure 7-3).

The airport has a 2002 m long and 45 m wide runway and can service all kinds of aviation comprising:

- Scheduled passenger traffic mainly to Copenhagen
- Charter traffic
- Cargo traffic
- General Aviation traffic (GA traffic)
- Search and Rescue traffic (SAR traffic)
- Military surveillance traffic

The airport is counted among the smaller airports in Denmark. The number of arriving and departing passengers for the period January 2020 – March 2022 are shown in Figure 6-1 underneath. The total number of arriving and departing passengers amounted to 135.000 in 2020 and 183.000 in 2021. The number of passengers for 2020 and 2021 were of course heavily influenced by the Corona pandemic.

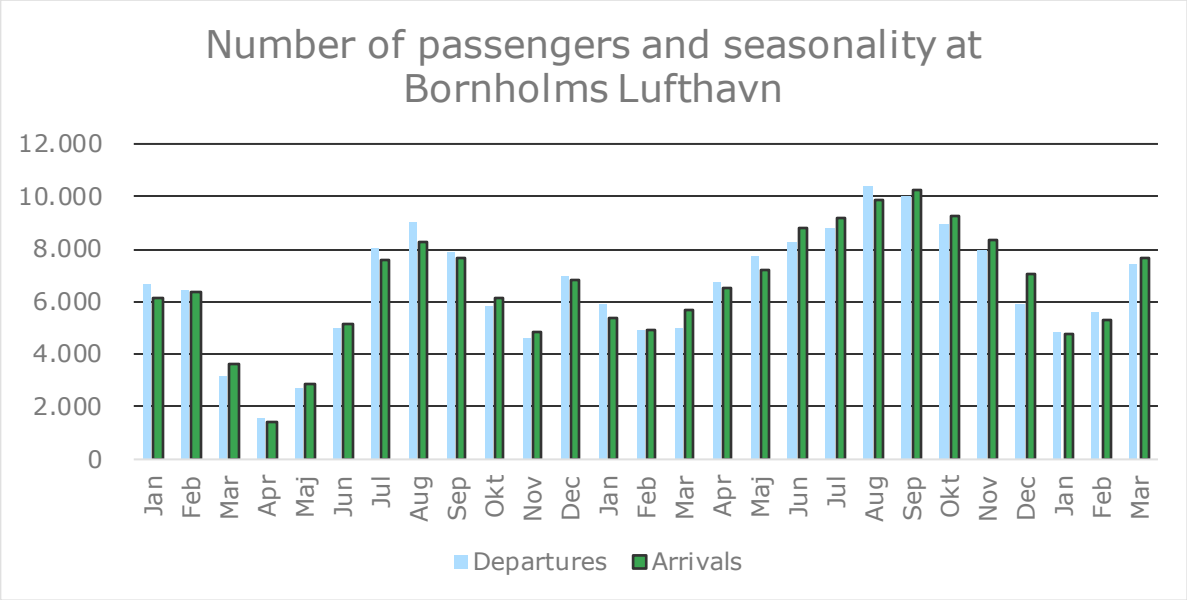

Figure 6-1 Number of passengers at Bornholms Lufthavn.

It is expected that the number of passengers and operations will increase substantially during the construction period for the wind farm and in the subsequent operational period. This will include an increase in workers traffic both with fixed wing aircraft to Bornholms Lufthavn and substantial helicopter traffic to and from the wind farm.

The airport is a so-called precision approach CAT 1, 4C airport meaning that it is equipped with instrumental landing systems for safe landings under poor weather conditions.

The airport is fully controlled by licensed Air Traffic Controllers. There is no civil airspace radar available. The Air Traffic Control is carried out by procedural management of the air traffic.

Figure 6-2 Runway at Bornholms Lufthavn.

Danish Air Transport (DAT) is the primary flight operator for passenger traffic to and from Bornholm. The analyzed Obstacle Limitation Surfaces (OLS) and procedures have been presented to DAT who has expressed acceptance of the analysis and procedures. DAT does not see a conflict between the passenger traffic to Bornholms Lufthavn and the wind farm project. This will be further elaborated in the following chapters.

7. IMPACT ASSESSMENT

7.1 Methodology

The following methodology is used for assessment of the different parameters:

Table 7-1 Criteria for significance of conflicts.

Overall significance of conflicts with air traffic	
Neutral/ no impact	No impact/conflict compared to status quo.
Minor negative impact	Potential conflicts exist and may lead to marginal or minor effects on the system. The system's ability to perform its functions is not significantly compromised.
Moderate negative impact	Overlap exists and may lead to potential deterioration of the system's performance.
Significant negative impact	Significant conflicts may lead to loss of system's ability to perform its function. Evaluation of mitigation strategies may be required.
Positive impact	There are positive impacts or benefits associated with installation of the proposed project.

7.2 The Obstacle Limitation Surfaces (OLS)

To secure safe air traffic and to protect the aircraft, the passengers and facilities on the ground, during approach and take-off it is important to establish obstacle free surfaces (OLS) around the airport as illustrated in Figure 7-1. The dimensions of the obstacle free surfaces are defined by the International Civil Aviation Organization (ICAO) and interpreted and controlled by the Danish regulatory body "Trafikstyrelsen".

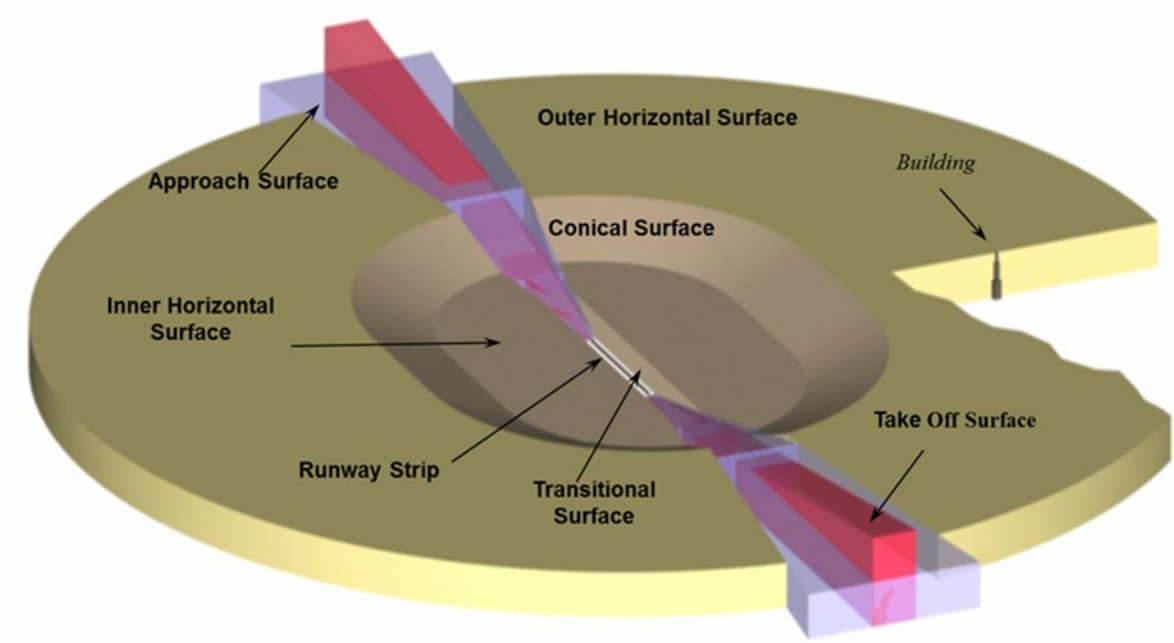

Figure 7-1 The Obstacle free surfaces.

Bornholm s Lufthavn is classified as an ICAO Code 4C airport. The physical non-obstacle requirements for this category are shown in the red box in Table 7-2.

Table 7-2 Dimensions of the Obstacle Limitation Surfaces (OLS), Ref. ICAO Annex 14.

	RUNWAY CLASSIFICATION									
	Non-instrument Code number				Non-precision approach Code number			Precision approach category I Code number		II or III Code number
Surface and dimensions[a] (1)	1 (2)	2 (3)	3 (4)	4 (5)	1,2 (6)	3 (7)	4 (8)	1,2 (9)	3,4 (10)	3,4 (11)
CONICAL										
Slope	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Height	35 m	55 m	75 m	100 m	60 m	75 m	100 m	60 m	100 m	100 m
INNER HORIZONTAL										
Height	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m
Radius	2 000 m	2 500 m	4 000 m	4 000 m	3 500 m	4 000 m	4 000 m	3 500 m	4 000 m	4 000 m
INNER APPROACH										
Width	—	—	—	—	—	—	—	90 m	120 m[e]	120 m[e]
Distance from threshold	—	—	—	—	—	—	—	60 m	60 m	60 m
Length	—	—	—	—	—	—	—	900 m	900 m	900 m
Slope								2.5%	2%	2%
APPROACH										
Length of inner edge	60 m	80 m	150 m	150 m	140 m	280 m	280 m	140 m	280 m	280 m
Distance from threshold	30 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m
Divergence (each side)	10%	10%	10%	10%	15%	15%	15%	15%	15%	15%
First section										
Length	1 600 m	2 500 m	3 000 m	3 000 m	2 500 m	3 000 m	3 000 m	3 000 m	3 000 m	3 000 m
Slope	5%	4%	3.33%	2.5%	3.33%	2%	2%	2.5%	2%	2%
Second section										
Length	—	—	—	—	—	3 600 m[b]	3 600 m[b]	12 000 m	3 600 m[b]	3 600 m[b]
Slope	—	—	—	—	—	2.5%	2.5%	3%	2.5%	2.5%
Horizontal section										
Length	—	—	—	—	—	8 400 m[b]	8 400 m[b]	—	8 400 m[b]	8 400 m[b]
Total length	—	—	—	—	—	15 000 m	15 000 m	15 000 m	15 000 m	15 000 m
TRANSITIONAL										
Slope	20%	20%	14.3%	14.3%	20%	14.3%	14.3%	14.3%	14.3%	14.3%
INNER TRANSITIONAL										
Slope	—	—	—	—	—	—	—	40%	33.3%	33.3%
BALKED LANDING SURFACE										
Length of inner edge	—	—	—	—	—	—	—	90 m	120 m[e]	120 m[e]
Distance from threshold	—	—	—	—	—	—	—	c	1 800 m[d]	1 800 m[d]
Divergence (each side)	—	—	—	—	—	—	—	10%	10%	10%
Slope	—	—	—	—	—	—	—	4%	3.33%	3.33%

a. All dimensions are measured horizontally unless specified otherwise.
b. Variable length (see 4.2.9 or 4.2.17).
c. Distance to the end of strip.
d. Or end of runway whichever is less.
e. Where the code letter is F (Table 1-1), the width is increased to 140 m except for those aerodromes that accommodate a code letter F aeroplane equipped with digital avionics that provide steering commands to maintain an established track during the go-around manoeuvre.

Note.— See Circulars 301 and 345, and Chapter 4 of the PANS-Aerodromes, Part I (Doc 9981) for further information.

It can be seen from the table that the inner horizontal surface is located 45 meters above the airports reference height (52 ft = 15,8 meters), which gives horizontal surface elevation height of 65 meters (DVR90).

The radius of the inner horizontal surface is 4.000 meters with a center in both runway thresholds (THR 29 and THR 11).

Outside the conical surface the outer horizontal surface is found, which has a positive slope away from the outer limitation of the horizontal surface. The slope is 5%.

Figure 7-2 Landing at Bornholms Airport.

Thus, the conic surface starts at elevation 65 meter and increases by 5% until a height of 115 meter is reached (100 meters over the reference height of the runway).

In addition to these surfaces there is an outer horizontal surface. This surface is not included in the Danish legislation as such, but it is stated in the Danish aviation law §67a that Trafikstyrelsen (TS) is responsible for all obstacles above 100 meters and must issue a certificate that the flight safety is not compromised.

The outer horizontal surface stretches to a distance of 15 kilometers from the airports reference point at elevation 165 (150 meters above the airport´s reference height). The planned wind farm with 330 meters height to the top of the highest wingtip must be located at least 15 kilometers from the airport's runway center point.

The following figures show the key assumptions, location and geometry of the wind farms named "Bornholm I" and "Bornholm II" related to the island of Bornholm.

A sketch drawing of the Obstacle Limitation Surfaces related to the two wind farms is shown in Figure 7-3. As it can be seen the location of Bornholm I and II will not interfere with the outer horizon for the instrument approach and landings with a 15 km distance between the wind farm (Bornholm I) and the airport.

Thus, there will be no conflict compared to status quo of the airport and the planned windfarms.

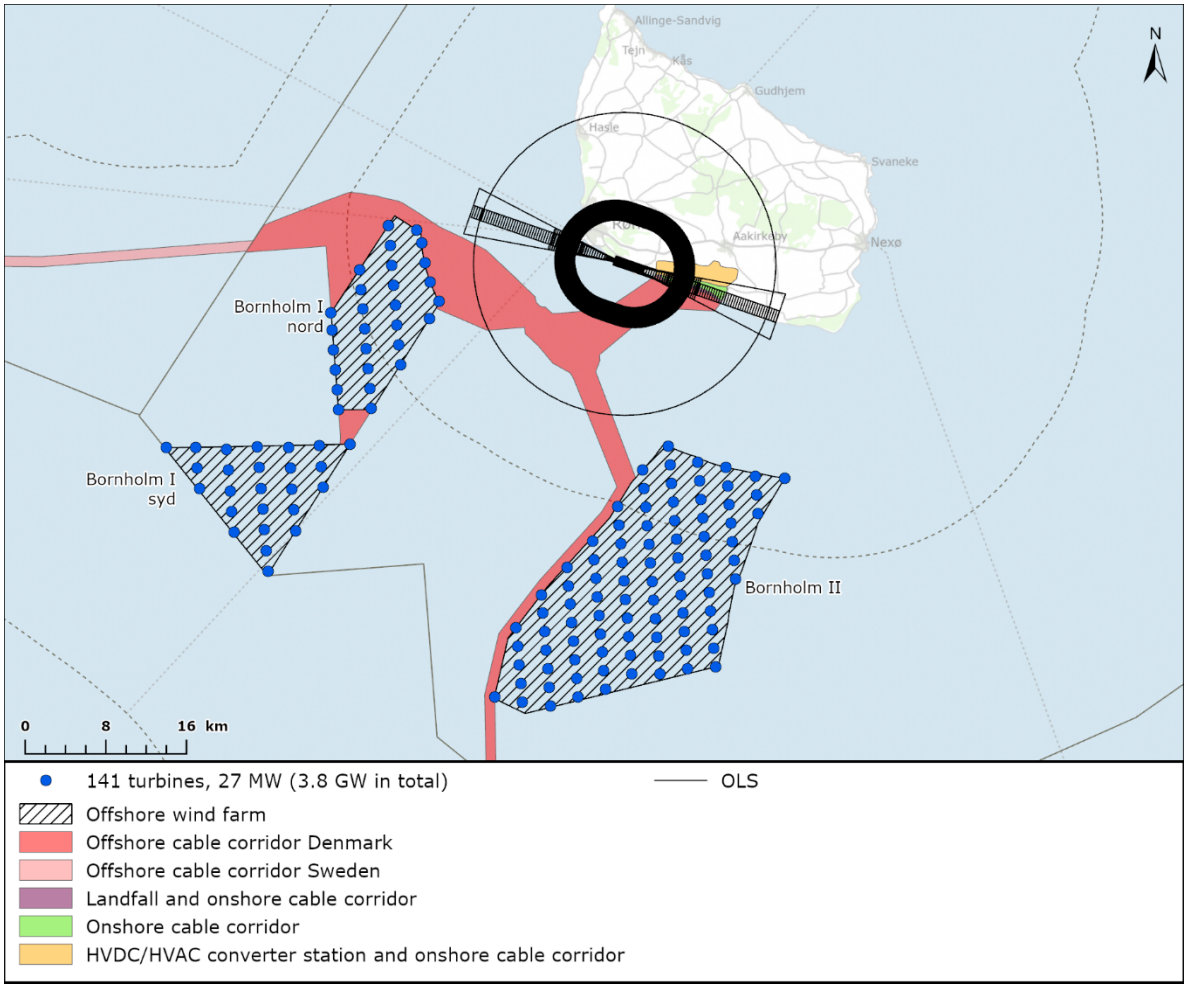

Figure 7-3 Obstacle Limitation Surfaces related to the two wind farms.

7.3 Approach and departure procedures

The following four figures show:

1. Basic ILS and OAS (Obstacle Assessment Surfaces) for ILS approach to Runway 11.
2. Design protection surfaces for VOR procedure for Runway 11.
3. Random Area Navigation (RNAV) procedures for approach to Runway 11.
4. Omnidirectional departure from Runway 29 with a turn from 500ft or 2000ft altitude.

We have shown the protection design for the final approach segment only as the other segments are not influenced. The conclusion is that none of the analyzed procedures and obstacle surfaces will be in conflict with the planned wind farms.

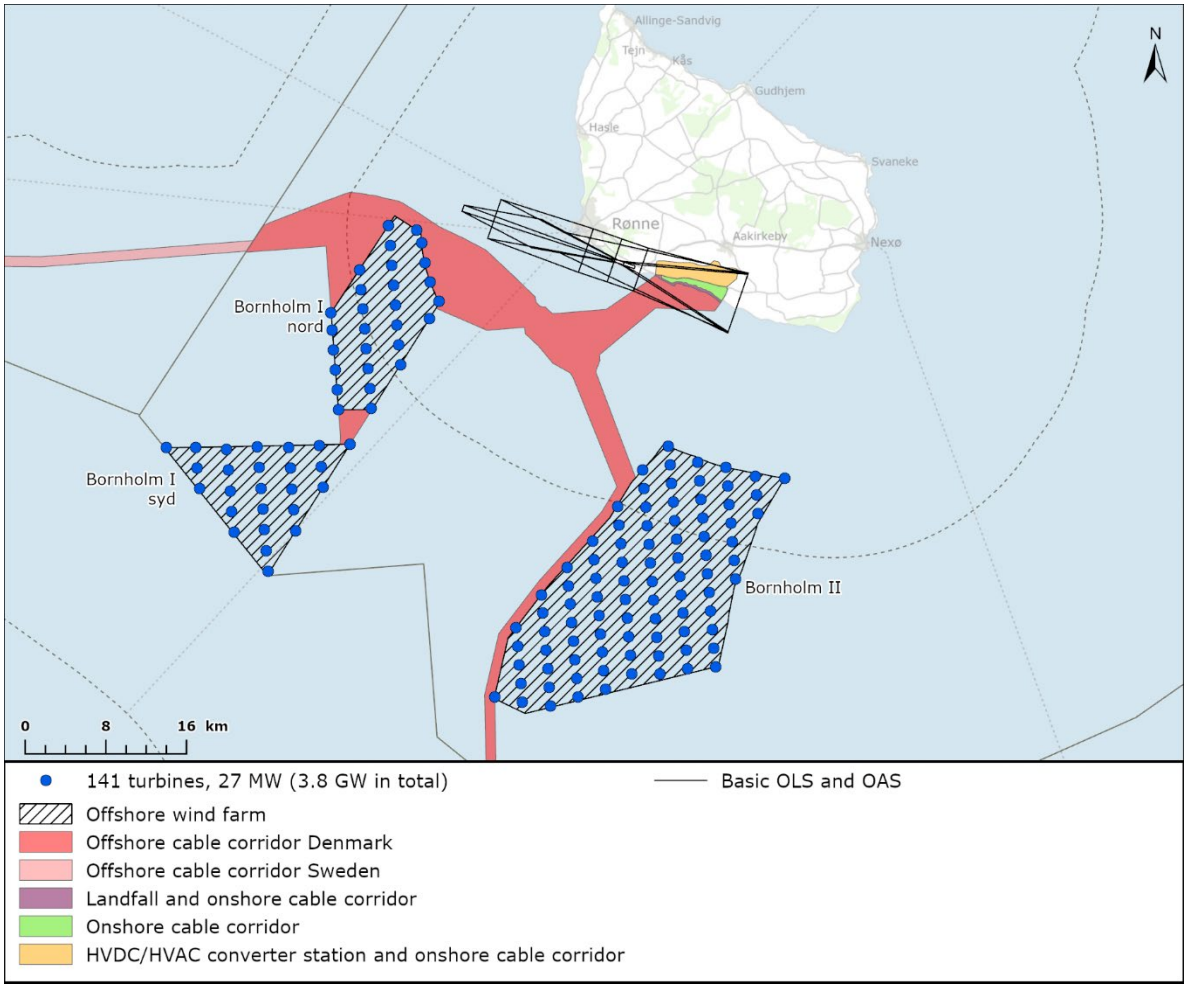

Figure 7-4 Basic OLS and OAS (Obstacle Assessment Surfaces) for ILS approach to Runway 11.

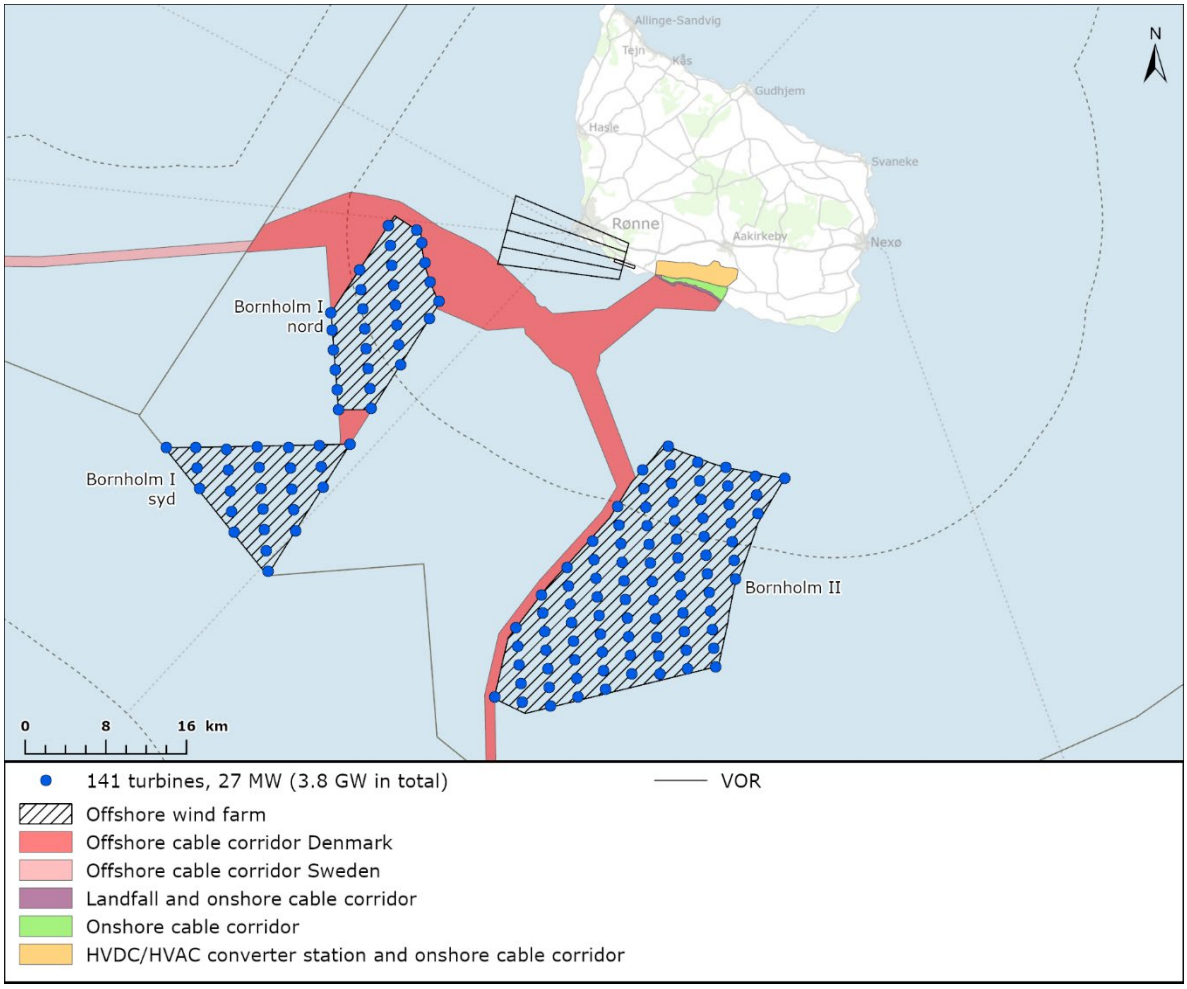

Figure 7-5 Design protection surfaces for VOR procedure for Runway 11.

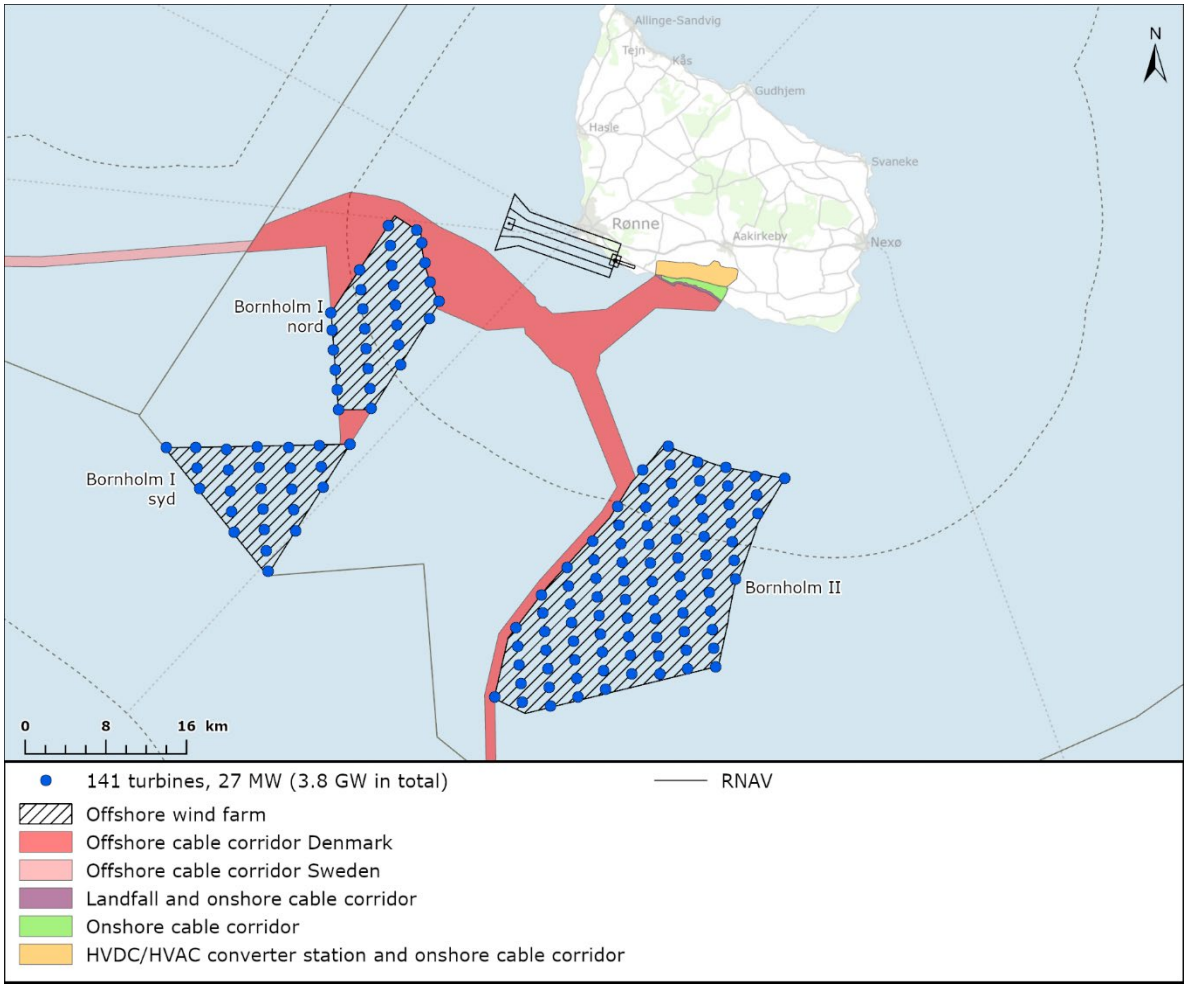

Figure 7-6 Design protection surfaces for RNAV procedure for Runway 11.

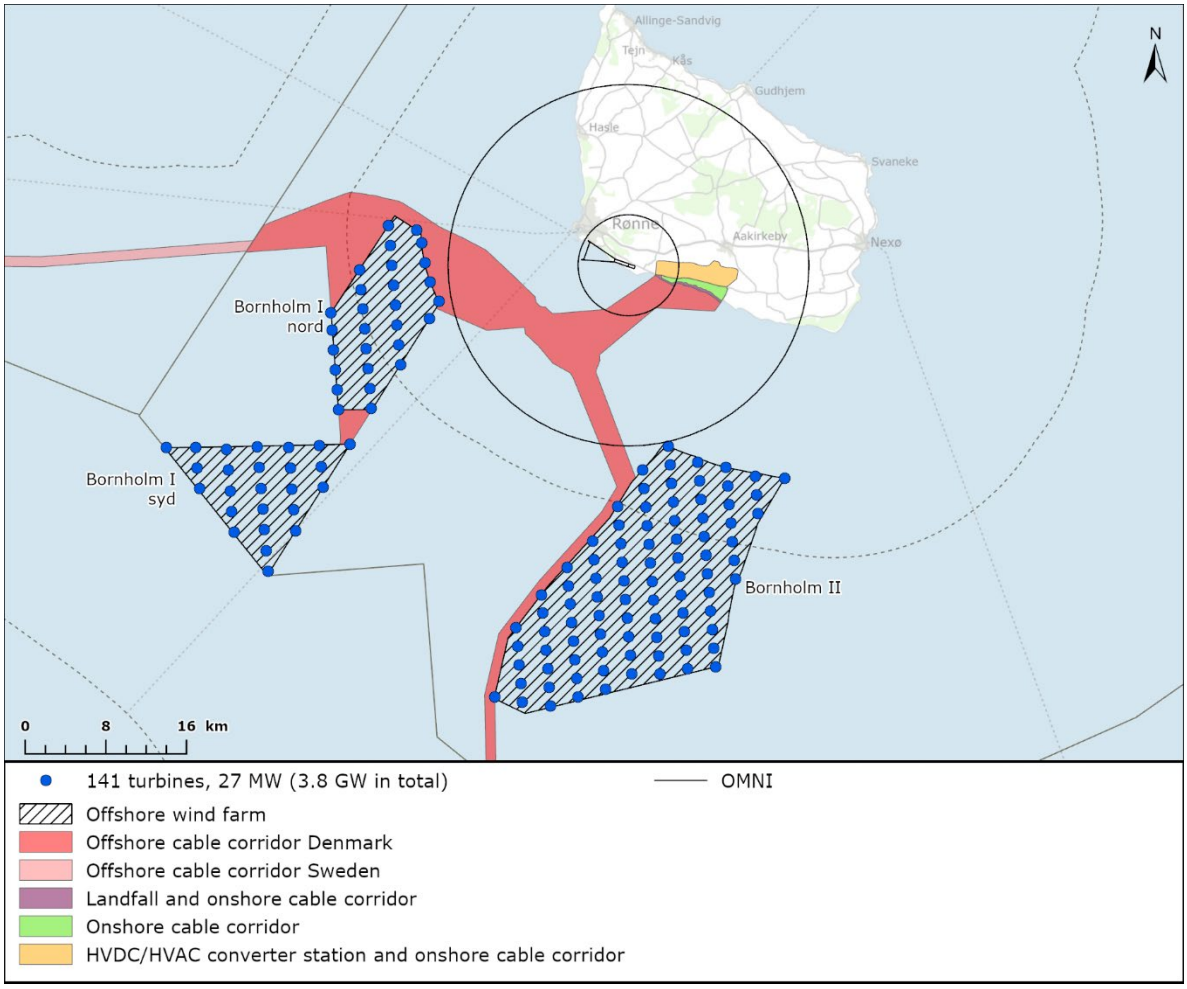

Figure 7-7 Omnidirectional departure from Runway 29 with a turn from 500ft or 2000ft altitude.

As it can be seen from the figures there will be no conflict compared to the existing procedures and the planned windfarms.

7.4 Onshore obstacles and installations

The above analysis relates to obstacles at sea. There will also be obstacles at land where the transformation and distribution of power will take place.

It is assumed that the transmission and distribution facility will be provided as a 400kV facility with a capacity of 3GW. The distribution facility will be an open-air facility, which will receive cables from the offshore wind farms and connect to cables for distribution to Zealand, Germany and Sweden.

It has been assessed by Energinet that the tallest buildings will have a height of maximum 25 meters, which will not conflict with the OLS surfaces. However, it is recommended that these buildings and towers will not be located directly under the approach and departures corridors for the runway and as far as possible to the east of the airport. The high Voltage substation may have structures (lightning protection above coupling bays), which can be higher than 25 meters. This should be included in the evaluation.

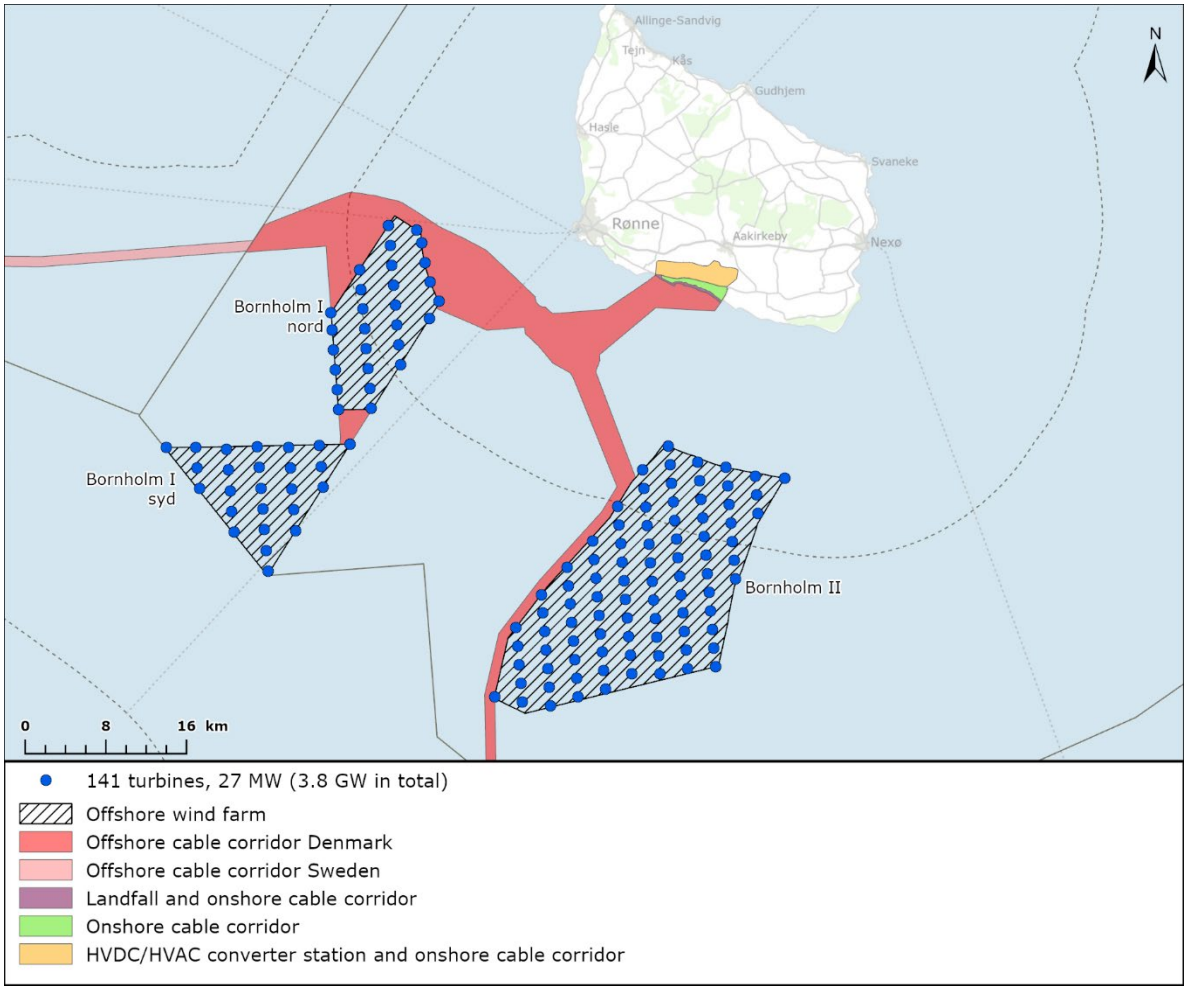

Figure 7-8 Location of the landside facilities.

Bornholms Lufthavn has Instrumental Landing Systems (ILS) at both runway ends, which potentially could be influenced by electrical arcs from the transformer and distribution systems.

However, based on experience from other airports (including Copenhagen Airport) with large electrical installations it is assessed that with a distance of more than 10 kilometers there will be no interference related to the location of the power stations and the navigational aids and consequently no conflict.

7.5 Helicopter traffic to the wind farms

Helicopters may be used during installation, commissioning, and operation of the wind farms.

Helicopters may serve for the transfer of personnel and cargo to the offshore substation, which will be equipped with a helideck. Transfer to the wind turbine will be possible by use of helicopter with a hoist.

Flying offshore for helicopter hoist operations is a most challenging task. Qualifications like flying according to instrument flight rules, hoist operations, multi-pilot, and offshore operations are all required. The airspace around the turbines is uncontrolled (i.e. it is not under radar or procedural control of an air traffic control unit. It is known as 'class G' airspace, meaning that the airspace is essentially open for anyone who wishes to use it and without requiring an air traffic control (ATC)

clearance. This is the case up to flight level 195 (FL195), which equates roughly to 19,500ft, above which the airspace is classified as 'class C' and can only be flown through with ATC clearance.

Based on the open airspace at the lower flight levels it is required that the helicopter operators will draft and develop a set of company rules and procedures for the operation of the helicopters to and from the turbines and between the turbines in the two wind farms. The flights will always be carried out under Visual Flight Rules.

Figure 7-9 Helicopter inspection of the turbines.

Even though the helicopters will fly in an open airspace it is recommended that all flights between the wind farms and Bornholm Airport will be performed with ATC clearance from the Tower in Bornholms Lufthavn.

As mentioned before flying helicopters to and from and between the turbines can be challenging and may have a marginal negative impact on the flight safety.

7.6 The use of drones

The use and development of drones for many purposes is going rapidly. It is assumed that drones will be used as a mean of transport of goods to the wind farms and maybe in the longer run also for transport of technical personal to and from the turbines. Smaller drones may be used for technical inspection of the towers and wings just as drones are used today for inspection of bridge pylons.

Drones are in principle to be considered as aircraft. The use of drones must be carried out in compliance with regulations from Trafikstyrelsen concerning procedures for operation of unmanned aircraft.

When applying to Trafikstyrelsen for an operational authorization the operator shall perform a risk assessment and submit it with the application, including adequate mitigating measures to avoid conflicts between the operation of drones and "normal" manned aircraft and helicopters.

Figure 7-10 Drones will be a mean of transport in the future.

The attention should specifically be payed to "BL 3-11 Bestemmelser om luftfartsafmærkninger af vindmøller" (guidelines for marking of turbines). The marking of the wind turbines and wind farms is important due to the height of the objects and the mowing wings.

The project in question comprises wind turbines that are more than 150 m in height and with a location outside the OLS surfaces. However, the wind turbines as mentioned above do not penetrate the OLS surfaces or compromise the approach and departure procedures.

The most important rules for location and marking of wind turbines outside the approach surfaces and with a height of more than 150 meters read as follows:

"The day-marking must as a minimum comprise white markings at the upper 2/3 of the towers and white markings at the wings and the nacelle.

The night marking for turbines *higher than 150 meters will comprise flashing high-intensive light. In the case of wind farms, the outer perimeter of the farm must be marked with a distance of maximum 900 meters between the individual mills".*

See the illustration at the front page of this report, Part II, page 25.

In BL-10 and BL-11 it is stated:
"Trafikstyrelsen (TS) has the possibility to issue dispensations related the BLs when it is assessed that it is in compliance with the Danish and international standards and that the level of safety is not compromised".

Thus, it is possible within the regulatory framework to provide some flexibility with respect to the marking of the wind turbines provided that safety is not compromised and that a proper supporting risk assessment is carried out.

7.7 The Danish Air Force

The Danish Air Force uses Bornholms Lufthavn for different purposes comprising mainly Search and Rescue (SAR) and protection of the Danish sovereignty in case the Danish airspace is violated by foreign powers.

7.7.1 Search and Rescue operations (SAR)

The SAR service is primarily carried out by the EH 101 helicopters from the Danish Air Force supported by the "Danish Air Ambulance" operating four EC135P2e ambulance helicopters.
The large EH 101 helicopters are based in Skrydstrup, Aalborg and Roskilde and in poor weather conditions a fourth helicopter is positioned in Bornholm´s Airport.

The Danish Air Force has its own operational rules and procedures. However, the Air Force has confirmed to Ramboll that the military SAR operations will comply with the civil requirements for VFR helicopter flights to and from Bornholms Lufthavn (BL 5-38).

Due to the nature of SAR operations it is accepted that certain procedures are interpreted in a flexible way – of course without compromising safety. This also goes for SAR operations comprising rescue missions related to the wind turbines.

It is assessed that no major impact will be imposed on the SAR operations from the new turbine parks.

7.7.2 Sovereignty

The protection of the Danish sovereignty in the Baltic Sea has become more and more important due to the political tense situation between NATO and Russia. In this respect Bornholm´s Airport has an important role as a base for fighter jets patrolling the Baltic area.

Due to the importance and urgency of such flights the Air Force is occasionally breaking the general civil ICAO rules and regulations to fulfil the military commitments and tasks.

However, also in this case the Air Force has confirmed that the military flight rules can be adjusted to comply with the civil rules and procedures taking into consideration the planned wind farms.

No new impacts or conflicts are expected as the military will follow the civil procedures as described above.

Figure 7-11 Bornholms Airport is the base for patrolling the Baltic Sea.

7.8 Construction of the wind farms

Possible operational conflicts may arise in the period of construction work and subsequently during the operational phases of the wind farm. It is likely that several dispensations will be required from Trafikstyrelsen to allow the construction work to be carried out.

Notams [3] will be issued to inform operators and pilots about granted dispensations with respect to the use of the airspace close to the construction field.
Thus, some marginal negative short term effects may be impacted from the construction of the windfarms.

Figure 7-12 Construction of a wind farm.

7.9 Overall risk analysis

The construction and operation of the planned wind farms with wind turbines could be as high as 330 meters within a distance of 15 km from Bornholm s Lufthavn will impose a theoretical potential risk to the air traffic to and from Bornholm Airport.

However, it should be noted that all European Air Service Agency (EASA) and BL safety rules and regulations will be followed, and it should particularly be noted that all OLS requirements regarding no-hindrance surfaces will be met and the procedures for approach and landings are not in conflict with the wind farms. This means that the risk of a collision between an airplane and a wind turbine is extremely small and acceptable from a regulatory point of view.

Furthermore, mitigating actions will be applied such as marking of the turbines and information from the air traffic control "Tower" to the pilots about the location and dimensions of the wind farms. Information of the wind farm obstacles will also be provided in the AIP – the pilots manual for operation to and from the airport.

[3] Notice to Air Missions

It should be added that the risk of an airplane/wind turbine collision is negligible for the midsized and larger aircrafts as these aircrafts are overall commercial flights, operated by professional pilots under instrument flight rules with equipment and procedures for operating in low visibility and low clouds conditions.

The main risk of a collision, if any, will be related to small planes operated by private pilots with limited experience and training operating under visual flight rules. It is suggested that the lower airspace around the wind farms south of the airport will be restricted to mitigate potential conflicts with such flights.

It is suggested, when all assumptions of the design and wind turbine configuration are known, that a final review of the risk analysis will be carried out.

8. CONCLUSION

At an overall level it is concluded that no serious conflicts between the planned wind farms and the air traffic to and from Bornholm Airport have been identified. Provided that the OLS distances and requirements are observed, and proper marking of the wind turbines is carried out we do not see that safety will be seriously compromised neither for the air traffic nor the wind farms.

9. REFERENCES

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/9/ OPERA, 2010a: " Site protection (wind turbines)", OPERA deliverable OPERA-2010-05, available at http://www.eumetnet.eu/sites/default/files/OPERA_2010_05_Wind_turbines.pdf

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APPENDIX I - RADIO CHAINS FROM THE DANISH FREQUENCY REGISTRY

Land mobile radio

C043070 - 2	167,1250	158,1250	Bofa I/S	Basisstation	Rønne

Sendeposition:

Adresse:	Torneværksvej 108
Postnummer:	3700
Bynavn:	Rønne
Antenne højde (m):	53
Kote (m): ?	50
Koordinater:	55N0703 014E4349
Geografisk anvendelse:	Punkttilladelse
Frekvensmaske:	

Tekniske specifikationer:

Sendeeffekt basisstation:	25 W
Sendeeffekt mobile anlæg:	25 W
Båndbredde (MHz):	0,025
Antal anlæg:	30 eller færre
MMSI:	
Kaldesignaltype:	
Frekvenskategori:	
Udstedelses-metode:	
Intention om overdragelse:	Nej
Intention om udlejning:	Nej
Udløbsdato:	31-12-2025

Brugerdata:

Brugernummer:	220350
Adresse:	Almegårdsvej 8
Adresse 2:	
Postnr.:	3700
Bynavn:	Rønne
Kaldesignal-kategori:	

Maritime /Aviation

LAN1047 - 19	156,0500	160,6500	Energistyrelsen	Kystradiostation	Rønne

Sendeposition:

Adresse:	Aarsballe By 55
Postnummer:	3700
Bynavn:	Rønne
Antenne højde (m):	84
Kote (m): ?	123
Koordinater:	55N0857 014E5252
Geografisk anvendelse:	Punkttilladelse
Frekvensmaske:	

Tekniske specifikationer:

Sendeeffekt basisstation:	50 W
Sendeeffekt mobile anlæg:	
Båndbredde (MHz):	0,025
Antal anlæg:	
MMSI:	
Kaldesignaltype:	
Frekvenskategori:	
Udstedelses-metode:	Først-til-mølle
Intention om overdragelse:	Nej
Intention om udlejning:	Nej
Udløbsdato:	31-12-2031

Brugerdata:

Brugernummer:	2393380
Adresse:	Carsten Niebuhrs Gade 43
Adresse 2:	
Postnr.:	1577
Bynavn:	København V
Kaldesignal-kategori:	

LAN0499 - 18	161,9750		Forsvaret	Maritim landstation	Rønne

Sendeposition:

Adresse:	Aarsballe By 55
Postnummer:	3700
Bynavn:	Rønne
Antenne højde (m):	298
Kote (m): ?	123
Koordinater:	55N0857 014E5252
Geografisk anvendelse:	Punkttilladelse
Frekvensmaske:	

Tekniske specifikationer:

Sendeeffekt basisstation:	12.5 W
Sendeeffekt mobile anlæg:	
Båndbredde (MHz):	0,025
Antal anlæg:	
MMSI:	002190077 - 002190077
Kaldesignaltype:	
Frekvenskategori:	
Udstedelses-metode:	Først-til-mølle
Intention om overdragelse:	Nej
Intention om udlejning:	Nej
Udløbsdato:	31-12-2030

Brugerdata:

Brugernummer:	2389445
Adresse:	Lautrupbjerg 1-5
Adresse 2:	
Postnr.:	2750
Bynavn:	Ballerup
Kaldesignal-kategori:	

LAN1061 - 1	161,9750		GAZ-System S.A.	Maritim landstation	Rønne

Sendeposition:

Adresse:	Kongensmark 4c
Postnummer:	3700
Bynavn:	Rønne
Antenne højde (m):	163
Kote (m): ?	119
Koordinater:	55N0936 014E5312
Geografisk anvendelse:	Punkttilladelse
Frekvensmaske:	

Tekniske specifikationer:

Sendeeffekt basisstation:	12.5 W
Sendeeffekt mobile anlæg:	
Båndbredde (MHz):	0,025
Antal anlæg:	
MMSI:	002194016 - 002194016
Kaldesignaltype:	
Frekvenskategori:	
Udstedelses-metode:	Først-til-mølle
Intention om overdragelse:	Nej
Intention om udlejning:	Nej
Udløbsdato:	31-12-2036

Brugerdata:

Brugernummer:	2397430
Adresse:	ul. Mszczonowska 4
Adresse 2:	
Postnr.:	02-337
Bynavn:	Warszawa
Kaldesignal-kategori:	

H030176 - 1	5600,0000-5650,0000		Danmarks Meteorologiske	Radar	Aakirkeby	

Sendeposition:

Adresse:	Flyvestation Bornholm
Postnummer:	3720
Bynavn:	Aakirkeby
Antenne højde (m):	
Kote (m):	?
Koordinater:	55N0719 014E5230
Geografisk anvendelse:	Punkttilladelse
Frekvensmaske:	

Tekniske specifikationer:

Sendeeffekt basisstation:	250000 W
Sendeeffekt mobile anlæg:	
Båndbredde (MHz):	50
Antal anlæg:	
MMSI:	
Kaldesignaltype:	
Frekvenskategori:	
Udstedelses-metode:	Først-til-mølle
Intention om overdragelse:	Nej
Intention om udlejning:	Nej
Udløbsdato:	31-12-2027

Brugerdata:

Brugernummer:	28035
Adresse:	Lyngbyvej 100
Adresse 2:	
Postnr.:	2100
Bynavn:	København Ø
Kaldesignal-kategori:	

Mobile phones

H101115 - 7	2170,0000-2185,0000	1980,0000-1995,0000	Inmarsat Ventures SE	Offentlige mobilnet	Rønne

Sendeposition:

Adresse:	Kongensmark 4C
Postnummer:	3700
Bynavn:	Rønne
Antenne højde (m):	52
Kote (m):	119
Koordinater:	55N0936 014E5313
Geografisk anvendelse:	Punkttilladelse
Frekvensmaske:	

Tekniske specifikationer:

Sendeeffekt basisstation:	4000 W
Sendeeffekt mobile anlæg:	
Båndbredde (MHz):	15
Antal anlæg:	
MMSI:	
Kaldesignaltype:	
Frekvenskategori:	
Udstedelses-metode:	Udbud
Intention om overdragelse:	Nej
Intention om udlejning:	Nej
Udløbsdato:	12-05-2027

Brugerdata:

Brugernummer:	2394026
Adresse:	5, rue Goethe
Adresse 2:	
Postnr.:	L-1637
Bynavn:	Luxembourg City
Kaldesignal-kategori:	

Radio / TV

Tilladelsesnummer/ Kaldesignal	Frekvenser (sende) MHz	Frekvenser (modtage) MHz	Navn	Tilladelsestype	Sendeposit
H031689 - 76	88,4000		DR	Landsdækkende FM-sendenet	Allinge
H031689 - 8	90,0000		DR	Landsdækkende FM-sendenet	Rønne
H031689 - 78	91,6000		DR	Landsdækkende FM-sendenet	Allinge
H100812 - 1	92,2000		Bauer Media ApS	Landsdækkende FM-sendenet	Rønne
H031689 - 80	93,7000		DR	Landsdækkende FM-sendenet	Allinge
H101190 - 2	94,3000		Bauer Media ApS	Lokale FM-sendere	Rønne
H031689 - 33	96,2000		DR	Landsdækkende FM-sendenet	Rønne
H101975 - 1	97,3000		Radio FM4 A/S	Landsdækkende FM-sendenet	Allinge
H031689 - 46	99,3000		DR	Landsdækkende FM-sendenet	Rønne
H101975 - 17	103,5000		Radio FM4 A/S	Landsdækkende FM-sendenet	Rønne
H100812 - 12	104,6000		Bauer Media ApS	Landsdækkende FM-sendenet	Nexø
H100812 - 15	105,7000		Bauer Media ApS	Landsdækkende FM-sendenet	Rønne
H100812 - 3	106,2000		Bauer Media ApS	Landsdækkende FM-sendenet	Aakirkeby
H101190 - 1	106,6000		Bauer Media ApS	Lokale FM-sendere	Rønne
H101191 - 1	107,1000		Bauer Media ApS	Lokale FM-sendere	Rønne
H100812 - 6	107,4000		Bauer Media ApS	Landsdækkende FM-sendenet	Allinge

Frequecy licenses of DR

FM	Frekvenstilladelse	H031689	
Sender	**P1/P2**	**P3**	**P4**
Hammeren	91.6 MHz / 0.035 kW	88.4 MHz / 0.035 kW	93.7 MHz / 0.035 kW
Årsballe	96.2 MHz / 30 kW	90.0 MHz / 30 kW	99.3 MHz / 30 kW

DAB	Frekvenstilladelse	H032855
Sender	**Effekt [W]**	**Frekvensblok**
Blykobbe	570	11C (220,352 MHz)
Dueodde Fyr	175	11C (220,352 MHz)
Hammeren	134	11C (220,352 MHz)
Nexø	200	11C (220,352 MHz)
Rø	315	11C (220,352 MHz)

DTT	Frekvenstilladelse	H101936
Sender	**Effekt**	**Frekvensblok**

DTT	Frekvenstilladelse	H101936
Gudhjem	25 W	40 (626 MHz)
Hammeren	50 W	40 (626 MHz)
Nexø	100 W	40 (626 MHz)
Rø	2,5 kW	40 (626 MHz)

APPENDIX II – SURVEY RESPONSE

Denmark	Date	Response Date	Response content
SFDE (St. for Dataforsyning og Effekt.)	3.11.21	8.11.21	not relevant for them
DMI (Danmarks Met. Inst.)	2.11.21	8.11.21	problem, when turbines at 25 km distance are higher than 208 m
ERST Erhversst.	3.11.21		no response
ENS (Energist.)	3.11.21	9.11.21	refer to frequency registry
Telia	3.11.21		no response
TDC	3.11.21	10.11.21	no problem, unless turbines emit radio-frequencies within the same band as TDC
3.dk	3.11.21		no response
Naviair	3.11.21	4.01.22	No concerns from a technical and operational perspective
Søfartsstyrelsen	3.11.21	23.11.21	Concerns regarding DGPS Hammerodde
DR	3.1.22	7.1.22	only minimal disturbance of receivers on Bornholm
Inmarsat SE	4.1.22		no response

Germany	Date	Response Date	Response content
DFS (Deutsche Flugsicherung)	9.11.21		no response
DWD (Deutscher Wetterdienst)	9.11.21	10.11.21	no objections
Telekom	9.11.21		ikke aktiv i DK
Vodafone	9.11.21		no response
Telefonica	9.11.21		no response
E-Plus	9.11.21		no response
Bundesnetzagentur	3.12.21		no response
GDWS	24.11.21	26./29.11.21	Interference with VHF-radio and radar frequneciels very unlikely

Sweden	Date	Response Date	Response content
Post- och telestyrelsen	15.10.21	02.11.21	refers to several operators, that should be included in the hearing
Telia Sverige AB	15.10.21	25.10.21	no objections
Hi3G Access AB	15.10.21	3.11.21	no objections
Teracom AB	15.10.21	22.10.21	no objections
Telenor Sverige AB /Net4Mobility	15.10.21	27.10.21	no objections
Luftfartsværket	03.11.21		no response
Lunds universitet avd för zoologisk ekologi	3.11.21	4.11.21	no objections
Nordvästra Skånes vatten & avlopp AB	3.11.21	4.11.21	no objections
SAAB AB	3.11.21		no response
SAAB Surveillance	3.11.21		no response
Sjöfartsverket	3.11.21	9.12.21	no objections
Stockholms universitet Meterologiska instituitionen MISU	3.11.21		no response
Trelleborgs Hamn AB	3.11.21		no objections
VA syd	3.11.21		no response