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PLAN FOR PROGRAMME ENERGY ISLAND BORNHOLM

Technical Report – Visibility assessment

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Contents

1 Summary

As input to the strategic environmental assessment (SEA) conducted for Plan for Programme Energy Island Bornholm, a visibility assessment was conducted by PlanEnergi in June 2022. The visibility assessment describes the expected visibility of the planned offshore wind farm (OWF) from the surrounding coastal areas of Bornholm, Sweden, and Germany.

The visibility assessment report defines key parameters affecting visibility. Such parameters include landscape conditions, viewer's location in terrain, the position of the wind turbines in relation to the coast, the curvature of the earth, and light and weather conditions.

The expected visibility is described for 15 MW and 27 MW wind turbines constructed within the planning area. Four theoretical park layouts are assessed, based on the assumption of a maximum production capacity of either 3.2 GW or 3.8 GW, a minimum distance of 15 km to the coast of Bornholm, and evenly distributed wind turbines:

A. 119 wind turbines of 27MW with a total height of 330 m (3.2 GW)
B. 214 wind turbines of 15 MW with a total height of 263 m (3.2 GW)
C. 141 wind turbines of 27 MW with a total height of 330 m (3.8 GW)
D. 254 wind turbines of 15 MW with a total height of 263 m (3.8 GW)

The distance from the surrounding coasts to the planning area of the planned OWF varies. Calculations show that the visual impact of the island of Bornholm ranges from coastal areas, dunes, cliffs, and hinterlands. In contrast, the visual effects on Germany and Sweden primarily focus on the coastal areas.

Example visualisations are prepared for seven selected visualisation points (Appendix 1). The assessment depicts the visibility in clear weather and conditions where the visibility is low, and the turbines have limited visual impact due to the distance to the planning area. Night-time visualisations are also prepared from select viewpoints.

The shortest distance from the surrounding coast to the planning area for the planned OWF is from the western coast of Bornholm. When viewed from there, the OWF will be visible and take up a large part of the horizon independently of the turbine size chosen. The distance from the southern part of Sweden is greater, and the OWF will be visible in clear weather. From Germany, the distance to the planning area is so significant that the OWF will, to a large extent, be hidden behind the earth's curvature, though turbines will still be visible on the horizon.

Other OWFs are present and planned in the Baltic Sea, and a cumulative visual impact is expected. Though limited, possible cumulative effects will be from Bornholm and Germany, where wind turbines will take up a considerable part of the horizon. No cumulative impacts are expected from the coasts of Sweden due to the distance to the OWF.

This visibility assessment serves as input to the SEA prepared for the Plan for Programme Energy Island Bornholm. Later, when an OWF developer is selected and the project design is decided, visualisations for the chosen park layout will be conducted as part of an Environmental Impact Assessment (EIA).

2 Introduction

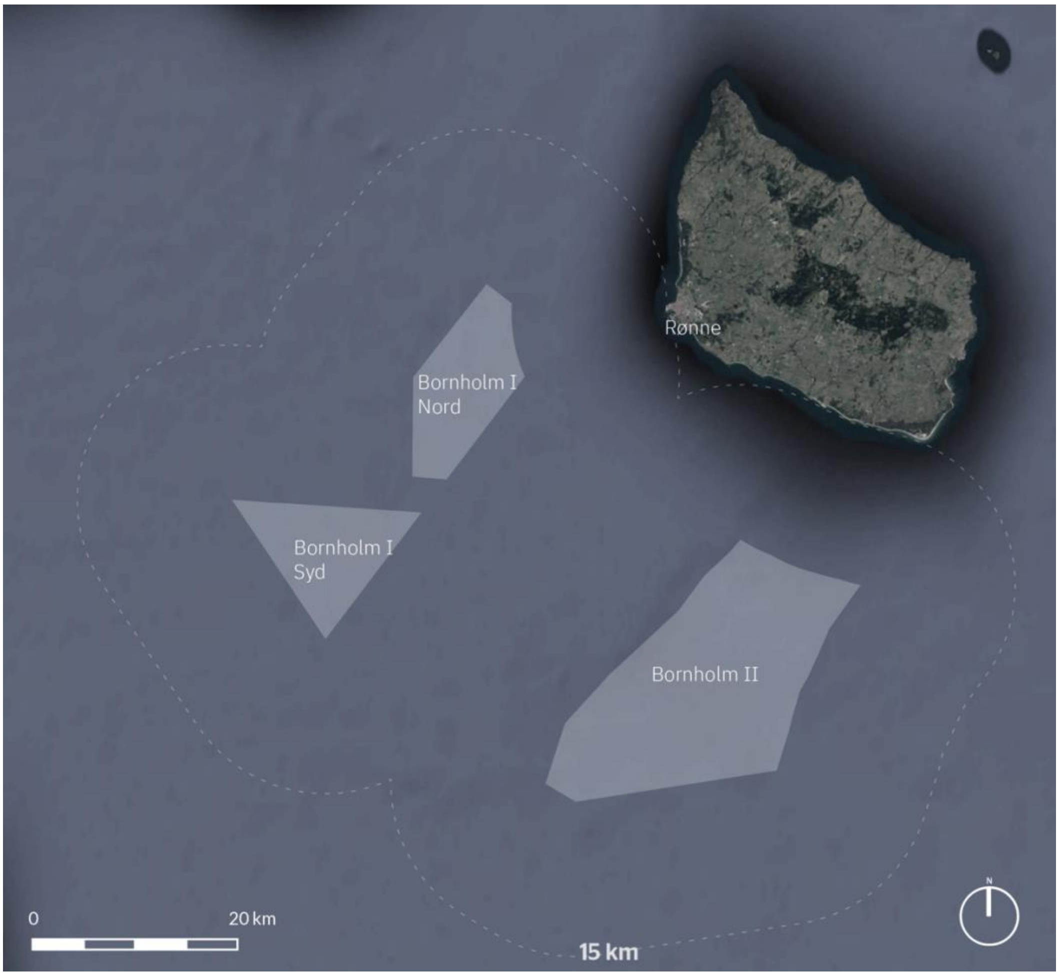

Figure 2-1. The designated planned OWF areas are Bornholm I Syd and Nord and Bornholm II. The wind farm is located southwest of Bornholm, at least 15 km from the coast.

The Energy Islands mark the beginning of a new era for energy generation from offshore wind, aimed at creating a green energy supply for Danish and foreign electricity grids. Operating as green power plants at sea, the islands will play a significant role in the phasing-out of fossil fuel energy sources in Denmark and Europe.

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

This visibility assessment aims to analyse where the OWF's of Plan for Programme Energy Island Bornholm will be visible from land and how visible it will be.

2.1 Background

In June 2020, a broad political majority within the Danish parliament agreed to initiate preparations for establishing the world's first Energy Islands, Energy Island Bornholm, and

Energy Island North Sea. The energy islands will enable the exploitation of the vast wind resources in the Baltic and North seas. They will serve as hubs, which can create better connections between energy generated from offshore wind and the regional energy systems.

The planned OWF at Bornholm is planned to operate by 2030. It consists of two planning areas located 15 km off the coast of Bornholm: Bornholm I divided into Syd (118 km^2) and Nord (123 km^2) and Bornholm II (410 km^2). The OWF is planned to have a production capacity of a minimum of 3.2 GW and a maximum of 3.8 GW.

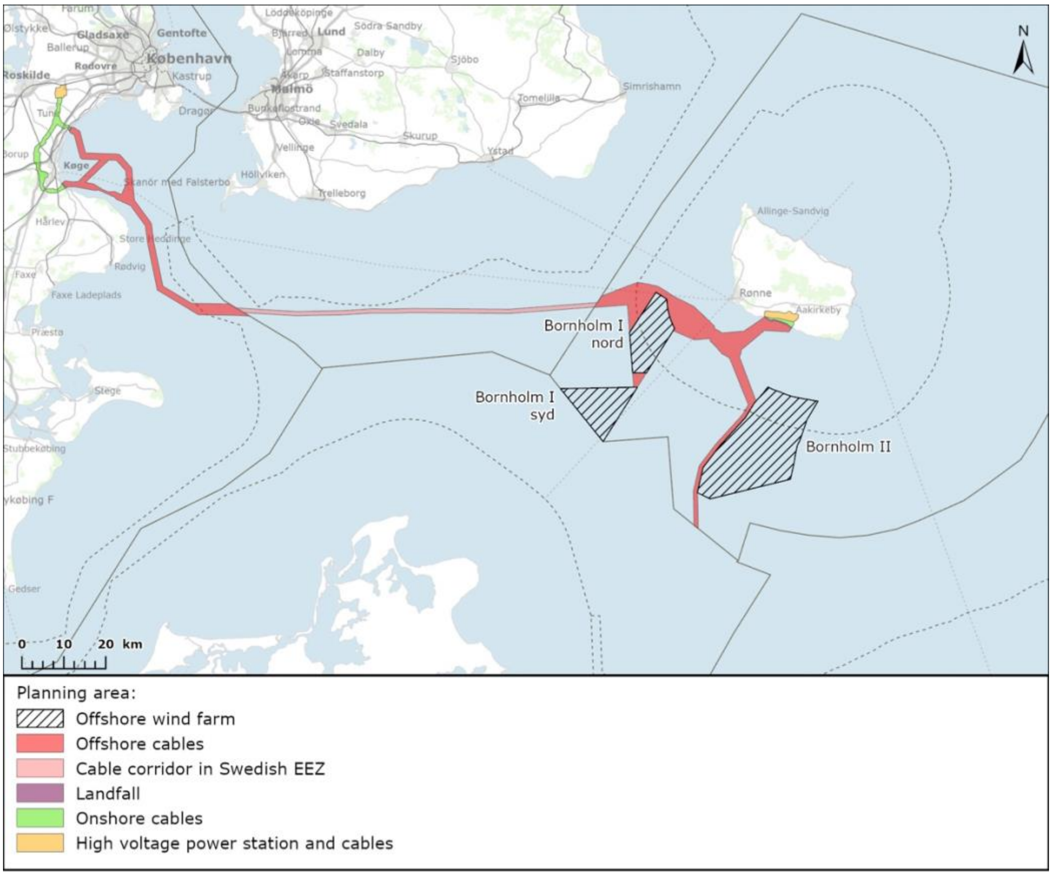

Figure 2-2: Planning area for Plan for Programme Energy Island Bornholm.

The scope of the Plan for Programme Energy Island Bornholm is described in a memo from the Danish Energy Agency (Energistyrelsen, 2022) issued concerning the 1st public phase of the SEA process.

2.2 Objective

This report aims to show the range of possible visibility from the planned OWF described in the Plan for Program Energy Island Bornholm on the surrounding Danish, Swedish and German coasts. The assessment is based on scenarios from setting up 15 MW turbines with a total height of 263 m or 27 MW turbines with a full height of 330 m because the final design for the concrete project is not decided until later by the selected OWF developer. The assessment aims to illustrate maximum visibility from the scenarios individually and in cumulation with other OWF projects.

The results serve as input to the SEA prepared for the Plan for Programme Energy Island Bornholm. The SEA includes an evaluation of potential visual impact from the realisation of the OWF described in the plan, including possible cumulative effects with other present and planned OWF.

First, this report describes the four theoretical park layouts subjected to visibility assessment that represent the range of possible visual influence from the realisation of the Plan for Programme Energy Island Bornholm. Next, the existing landscape conditions are described (baseline), focusing on the overall characterisation of the surrounding coastal areas. Then, the OWF's theoretical visibility is assessed based on, i.e., the earth's curvature, visibility, and Zone of Visual Influence (ZVI) calculations. Finally, the OWF's illustrated visibility is evaluated based on seven example visualisations from the surrounding Danish, Swedish and German coasts. Example visualisations are enclosed in Appendix 1 since a full-page format (A3) is required to illustrate the expected visibility.

3 Methodology

Several different parameters have an impact on the visibility of offshore wind turbines.

For example, the landscape conditions are crucial to whether there are shielding elements or unobstructed sea views. From areas with a view of the open sea, visibility will also depend on the viewer's location in the terrain.

In addition, the location of the wind turbines with the coast and the project's design impact visibility. Therefore, it will be necessary to take one or more theoretical park layouts as a starting point in this analysis work.

Finally, the actual conditions have an impact on visibility. In this context, the curvature of the earth, as well as light conditions and weather, must be included in the analysis.

3.1 Scenarios for Energy Island Bornholm OWF

The report defines key parameters affecting visibility. Such parameters include landscape conditions, viewer's location in terrain, the position of the wind turbines in relation to the coast, the curvature of the earth, and light and weather conditions.

The expected visibility is described for 15 MW and 27 MW wind turbines constructed within the planning area. Four theoretical park layouts are assessed, based on the assumption of a maximum production capacity of either 3.2 GW or 3.8 GW, a minimum distance of 15 m to the coast of Bornholm, and evenly distributed wind turbines:

A. 119 wind turbines of 27MW with a total height of 330 m (3.2 GW)
B. 214 wind turbines of 15 MW with a total height of 263 m (3.2 GW)
C. 141 wind turbines of 27 MW with a total height of 330 m (3.8 GW)
D. 254 wind turbines of 15 MW with a total height of 263 m (3.8 GW)

Wind turbine	Scenario A (3.2 GW)	Scenario B (3.2 GW)	Scenario C (3.8 GW)	Scenario D (3.8 GW)
Number of turbines	119	214	141	254
Capacity, MW	27	15	27	15
Total height of the turbine, m	330	263	330	263
Hub height, m	180	146.5	180	146.5
Rotor diameter, m	300	233	300	233

Table 3-1: The design parameters relevant for the visibility assessment of the OWF

3.2 Park layouts

For each of the turbine sizes, 15 MW and 27 MW, specific layouts have been developed to support the visualisations and other parts of the visibility assessment. The layouts reflect the maximum production capacity of either 3.2 GW or 3.8 GW. The layouts assume an even distribution of turbines within the planning area. Rotor overhangs outside the planning area are allowed, except towards the Danish-German EEZ.

Figure 3-1 shows the four layouts in comparison, where layouts based on 15 MW turbines produce a higher turbine density, while layouts based on 27 MW turbines result in a lower turbine density.

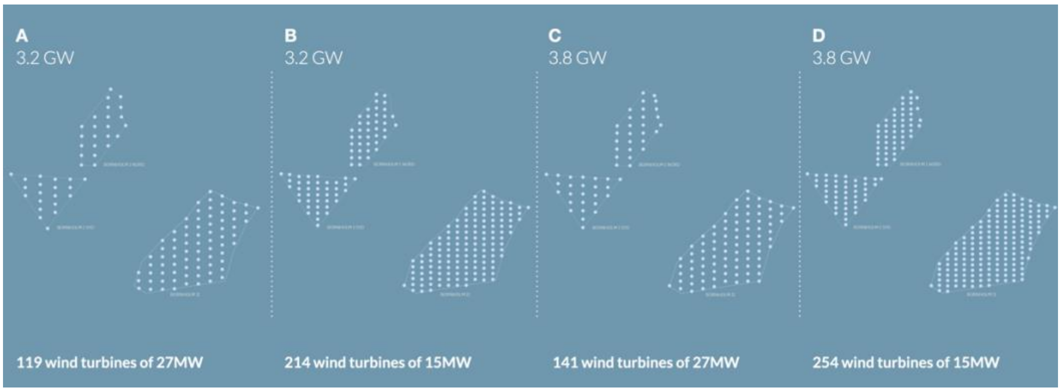

Figure 3-1 Illustrations of the park layouts used as the basis for the visibility assessment for both the theoretical visibility and, for example visualisation.

3.3 Existing conditions

The distance between the surrounding coasts and the OWF areas of Plan for Programme Energy Island Bornholm varies from approx. 15-68 km. The distance from selected relevant viewpoints on the coast to the nearest boundary of the planning area is illustrated in figure 3-2.

The description of the existing landscape conditions includes coastal stretches and the Bornholm hinterland approximately 50 km from the nearest boundary of the planning area. This is because the turbines' visibility of more than 50 km will be limited, see section 5 Theoretical visibility.

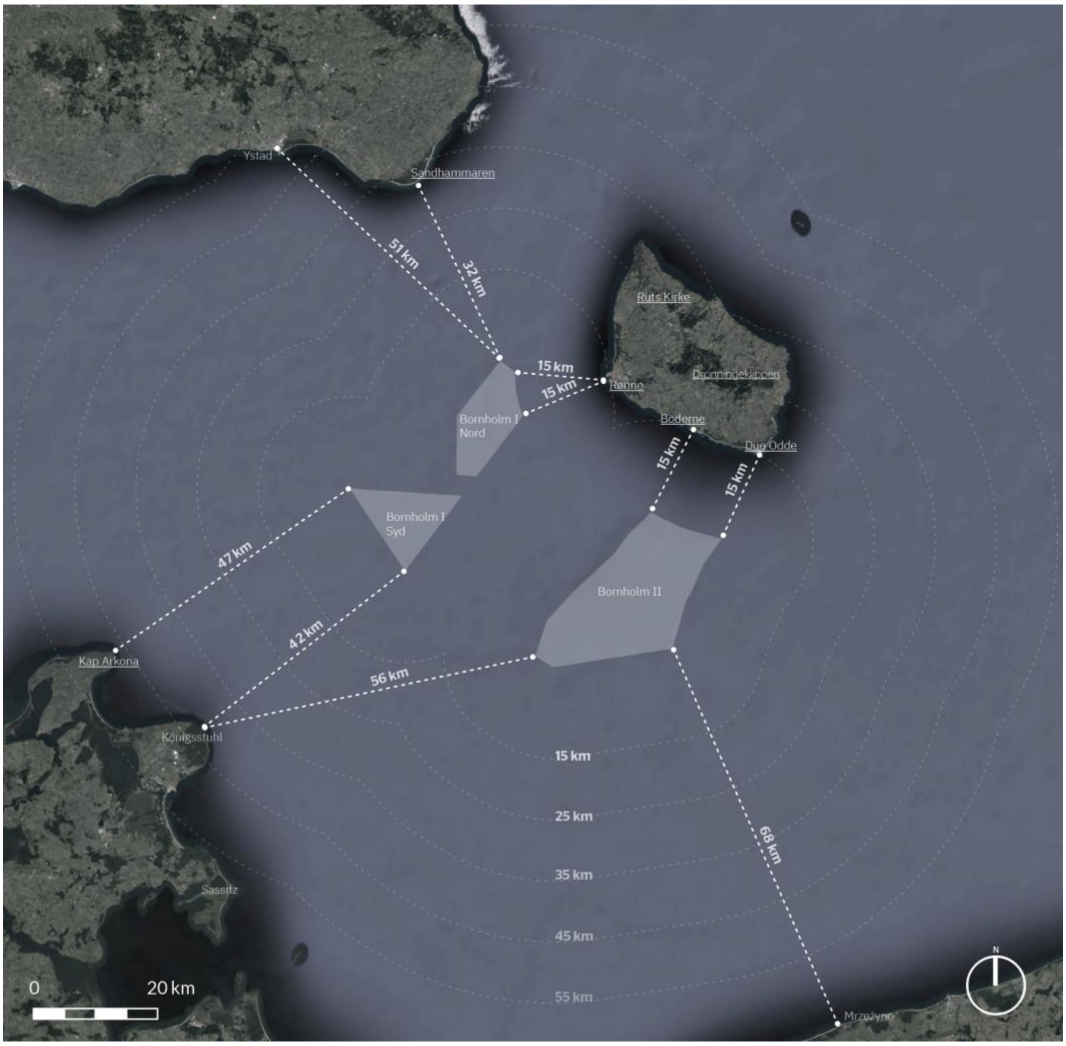

Figure 3-2Map showing the surrounding coastlines along Rugen, southern Sweden, and Bornholm. The map indicates the distance between the OWF areas of Plan for Programme Energy Island Bornholm from the coastal regions at Bornholm, Sweden, Germany, and Poland. The underlined text indicates viewpoints from which example visualisations have been prepared and presented in appendix 1.

3.4 Theoretical visibility at sea

The theoretical visibility chapter describes the OWF's theoretical visibility from the surrounding shores based on the earth's curvature, statistical visibility, the number of turbines, and the size of the turbines contained in the four scenarios.

The theoretical visibility illustrates the significance of the earth's curvature and maps with calculations of the visual impact (ZVI).

3.5 Visual representation of the OFW

To illustrate the visual impact of the OWF, seven example visualisations have been prepared from the coasts of Bornholm, Sweden, and Germany, as well as from the hinterland at Bornholm. The visualisations are shown in Appendix 1.

The visualisations are prepared to exemplify the visibility of the OWF if offshore wind turbines are installed in the entire planning area and thus utilise the maximum planning capacity of 3.2

GW or 3.8 GW. This also means that the visualisations show the offshore wind turbines with a location as close to land as the plan allows, and thus the highest visibility from the coast.

Visualisations have been prepared from 7 selected relevant viewpoints, at distances varying from approx. 15 km to approx. 47 km. Thus, the visualisations represent the extent of expected visual impact from all surrounding coasts within approximately 50 km.

Viewpoint	Scenario A (3.2 GW)	Scenario B (3.2 GW)	Scenario C (3.8 GW)	Scenario D (3.8 GW)
1. Galløkken	X	X	X	X
2. Boderne	X	X	X	X
3. Due Odde	X	X	X	X
4. Ruts Kirke	X	X	X	X
5. Dronningeklippen	X	X	X	X
6. Sandhammaren (SE)	X	X	X	X
7. Kap Arkona (DE)	X	X	X	X

Table 3-2: The viewpoints from which example visualisations have been made. Scenario A-D is illustrated in daylight with maximum visibility from all seven viewpoints. From viewpoint 1 Galløkken (Rønne), the OWF is also presented in dim light and night. Bornholms Regionskommune (the municipality of Bornholm) has provided their input to the selection of viewpoints, including additional suggestions they wish to have included for the visualisations relating to the EIA of a future concrete project. All viewpoints provided by Bornholms Regionskommune are outlined in table 6-1.

3.6 Data used in the report

To describe existing conditions, topographical maps have been used.

Mathematical formulas have been used to calculate the earth's curvature to analyse the theoretical visibility at sea, and ZVI calculations have been made in WindPRO (a software that uses a mix of CAD and GIS software functions) to illustrate the probable visibility of the OWF from the surrounding coastal landscapes. The statistical visibility is presented based on data from the measuring stations at Bornholm Airport.

To illustrate the maximum expected visibility of the planned OWF of Bornholm, photos have been taken from 7 viewpoints along the coasts and the hinterland of Bornholm and the shores of Sweden and Germany. The recorded photographs have been used to prepare example visualisations. Please refer to Appendix 1 for a more detailed description of the method and data basis for preparing visualisations.

4 Landscape typology

In the following, the relevant coastal landscapes of Bornholm, Sweden and Germany are described with overall characteristics, landscape value and visual relation to the Baltic Sea.

The landscape typology is essential for the visibility of the wind turbines, and analysis, therefore, requires some understanding of the structure of the landscape and the landscape context.

It is of great importance for the visibility of offshore wind turbines where the observer is positioned in the landscape. Along the coastline, there are generally two possible scenarios for views of the sea, where the observer is situated differently in the terrain - from the coast and dunes and cliffs.

Bornholm's western coast is characterised by Rønne city and harbour, which is centrally located on the low-lying flat terrain closest to the coast. Behind the town, the terrain rises markedly towards the surrounding more undulating agricultural landscapes.

Around Rønne, the landscape is characterised by forests and lakes. There are sandy beaches and larger forest areas to the north and south.

From the beaches, there is nothing to obscure the view of the water, and the relatively straight stretch of the coast allows for long sights along the coastline. See Figures 4-1 and 4-2.

Figure 4 -1 Rønne is where the west and south coasts around Bornholm meet. The city has both central harbour areas and a relatively large coastline that extends to the southeast past beach and residential areas along Strandvejen.

Figure 4 -2 Sandhammaren, approx. 26 km east of Ystad is one of Sweden's largest coastal areas. The wide sandy beach is the southernmost part of Sweden, and thus, the point from Sweden closest to Bornholm I.

4.1 The dunes and cliffs

White continuous sandy beaches characterise Bornholm's southwest coast with dunes and a few sandstone reefs. See figure 4-3.

The scale of the landscape is relatively compact, with overgrown dunes and forests of pine trees, while along the beach, the scale is large with sweeping views of the sea.

The building structure is formed by holiday homes in delimited areas hidden by the forest on natural plots.

Cliffs along the North Sea vary in height, and from the top of the cliffs, there are often sweeping views of the sea. At Kap Arkona and Königstuhl at the Island of Rügen in Germany, the cliffs are respectively 45 and 117 m above sea level, and from here, there are sweeping views over the sea. See figure 4-4 and 4-5.

Figure 4 -3 The beaches around Due Odde are Bornholm's southernmost point. In addition to an open sea view, Due Odde is a large holiday area with sandy beaches.

Figure 4 -4 Königsstuhl is a 118-meter-high chalk stone formation in the Jasmund National Park on the German island of Rügen. It is located 7 km north of Sassnitz and 4 km southeast of Lohme. The area around Königsstuhl has an open view over the Baltic Sea.

Figure 4 -5 Kap Arkona is 42 m above sea level on the northeastern tip of the island of Rügen, near the village of Putgarten. The geography allows for an open sea view, and Kap Arkona is a popular excursion destination.

4.2 The hinterland

At Bornholm, the landscape behind the coast and dunes is characterised by cultivated fields, and it is a landscape on a large scale characterised by large flat fields. The terrain slopes evenly from the high-lying forest areas in the middle of the island and down to the south. The expansive landscape views south over the sea are characteristic of this part of the hinterland. The open field landscapes are broken by wooded streams that meander through the landscapes. See 4-6 and 4-7.

Figure 4 -6 In the northern part of Bornholm, approx. 2.6 km from the coast and immediately north of the village Rutsker is Ruts Church. The church is located very high in the landscape, approx. 130 m above sea level and offers a view of a large part of northern Bornholm and a long sea view.

Figure 4 -7 From Dronningeklippen, an area above Ekkodalen in the hinterland. Large and small forests characterise the area, and the terrain is varied and high-lying.

5 Theoretical visibility

Several factors affect the visibility of objects over the sea. In contrast to visibility on land, where landscape forms, planting and buildings quickly limit visibility, there are often free viewing opportunities at sea.

5.1 The curvature of the earth

The curvature of the earth influences the visibility of offshore wind turbines. From the beach edge at an eye level of approx. 2 m above sea level, the horizon will theoretically be 5 km out to sea. Elements at sea within this distance will thus be able to be seen to their full extent. If a wind turbine is placed further away, however, the earth's curvature means that the lower part of the turbine tower disappears behind the horizon. The further away the wind turbine is from the point of view, the more the turbine will be hidden.

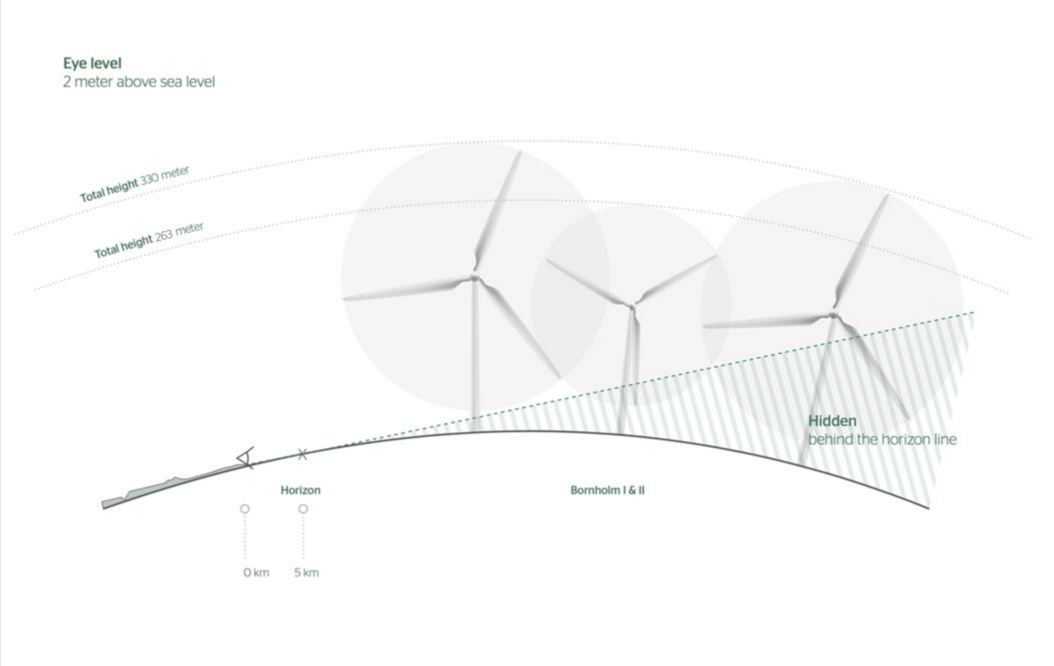

Figure 5-1Visibility from 2 m above sea level. The earth's curvature affects the visibility of offshore wind turbines, which at longer distances disappear below the horizon line.

Figure 5-1 illustrates an example of the visibility of offshore wind turbines with a total height of 330 and 263 m, located a minimum of 15 km from the coast. The diagram thus shows how visible the offshore wind turbines will be from the observer's position, i.e., maximum eye height of 2 m above sea level. The chart also illustrates the importance of distance and when turbines will be partially hidden below the horizon.

The earth's curvature means that when the nearest wind turbine, at 15 km from land, is visible from the coast, the lowest 8 m of the turbine is hidden behind the horizon. At 25 km, 31 m of the turbine is hidden behind the horizon, and at 40 km, 96 m of the turbine is hidden behind the horizon. From Rønne, the distance to the farthest corner of the designated area of Bornholm II is 47 km. Due to the earth's curvature, 139 m of a turbine will be hidden behind the horizon at this distance.

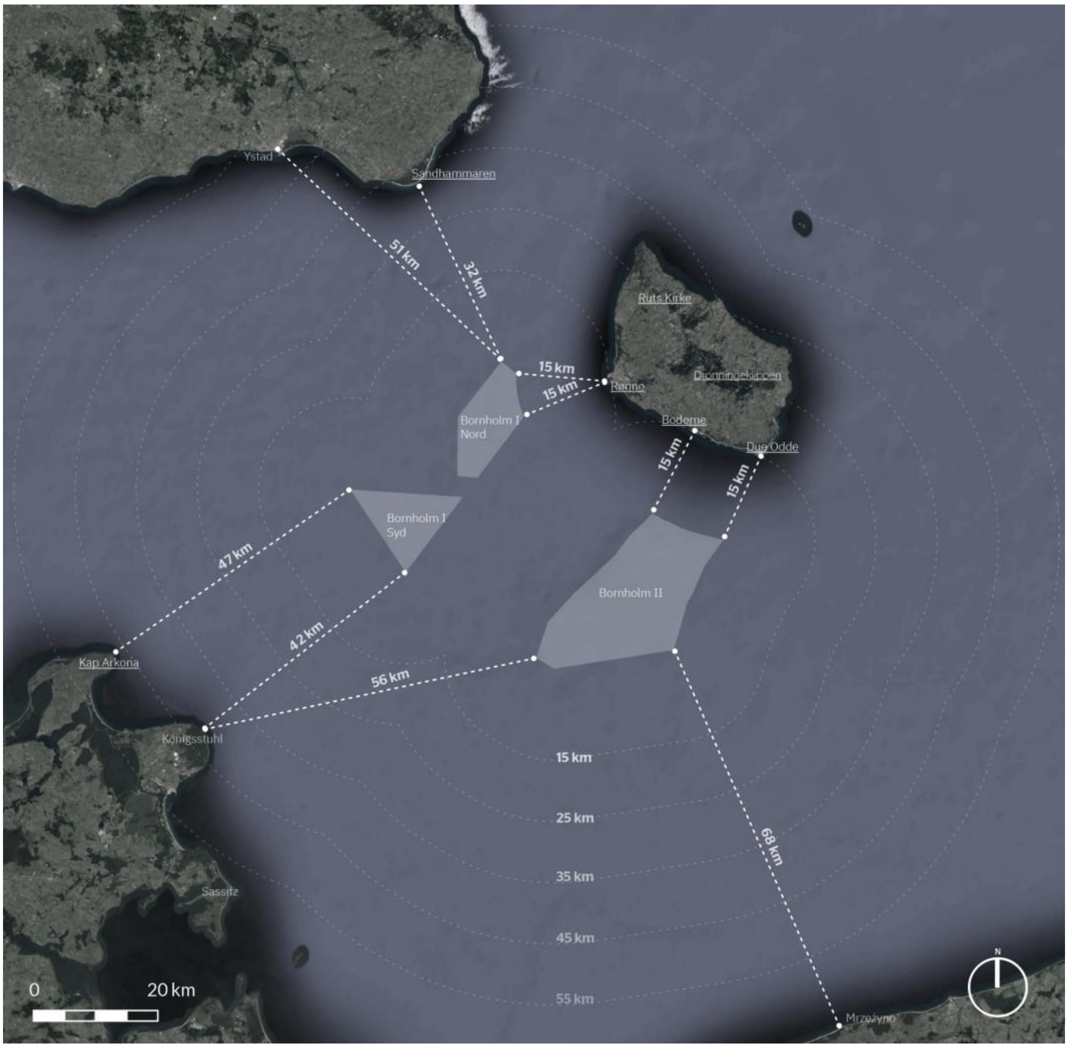

Figure 5 -2 shows the surrounding coastlines along Rugen, southern Sweden, and Bornholm. The map indicates the distance to the planning area for the OWF from the coastal regions at Bornholm, Sweden, Germany, and Poland.

The size of the planning area combined with the earth's curvature means that there will be a significant difference in the visual impact of the turbines within the planning area.

At optimal weather conditions, i.e., in clear weather, an offshore wind turbine can be registered as an object on the horizon at a maximum distance of approx. 55 km. But even under optimal weather conditions, the visibility of objects at great distances is reduced due to the moisture content of the air (BIRK NIELSEN, 2007). See section 5.2.

5.2 Visibility

The overall air clarity is of great importance for the visibility of the OWF. The clarity of the air depends on weather conditions, including light and air humidity.

Visibility is divided into five intervals:

- Fog: 0 – 1 km
- Low visibility: 1 – 4 km
- Moderate visibility: 4 – 10 km

- Good visibility: 10 – 19 km
- Maximum visibility: above 19 km

The distances from the coasts to OWF areas of Plan for Programme Energy Island Bornholm range from 15 km to 68 km, and thus the OWF will primarily be visible from the surrounding coasts when the visibility is in category maximum visibility.

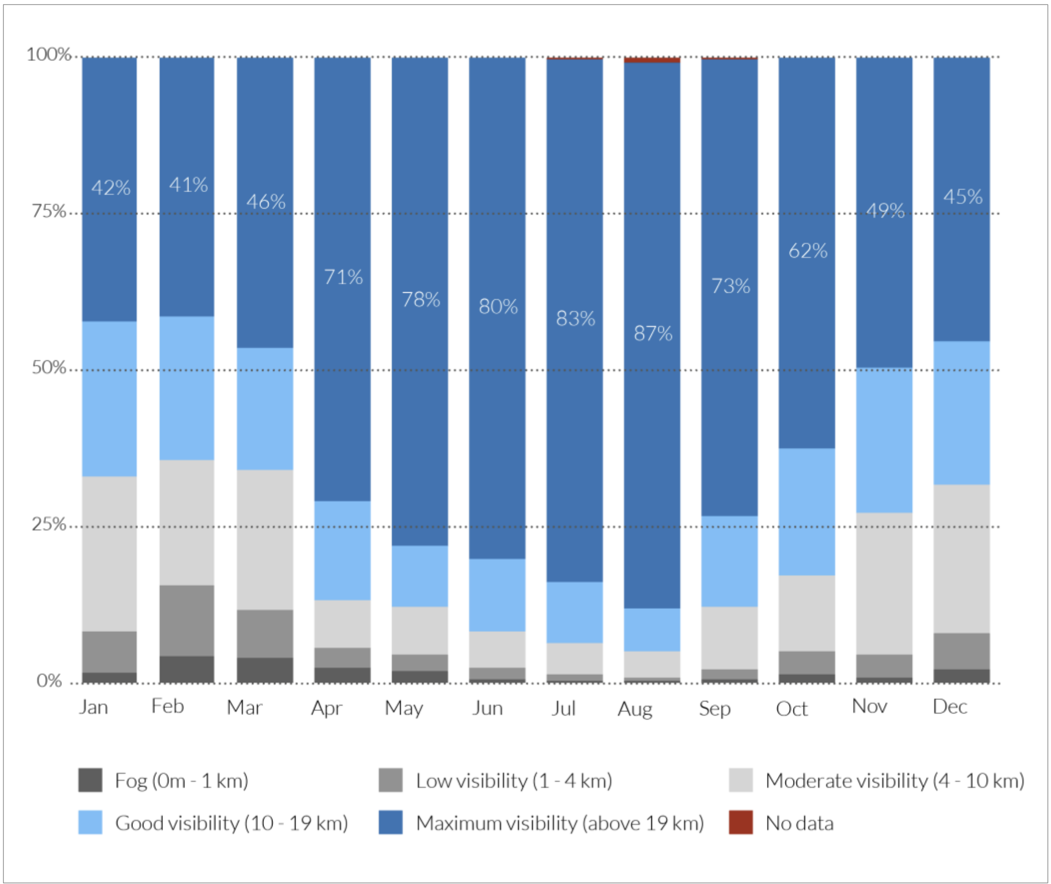

Figure 5-3Visibility statistics for the Baltic Sea measured at Bornholm Airport (DMI, 2017-2021).

Figure 5-3 shows a chart of measured visibility from the measurement station at Bornholm Airport near Rønne on Bornholm's west coast. The chart is based on five years of data collected from January 2017 to and including December 2021 (DMI, 2017-2021). The chart thus shows a statistically representative picture of the visibility. The dark blue colour shows the percentage of the individual month where the visibility was in the "maximum visibility" category, i.e., with a visibility of more than 19 km.

The diagram shows that in the period April to October maximum visibility can be expected for at least 60% of the time and in periods up to 87% of the time, while in the winter months maximum visibility can be expected for approx. 40-45% of the time.

During the year, there are very few days with a visibility lower than 4 km.

Visibility is defined here as the maximum horizontal distance in which a black object of an extent of between 0.5 ° and 5 ° can be seen and identified against a light-scattering background (sky, fog, etc.) under normal daylight conditions. The distances in the visibility statistics are, therefore, not a manifestation that the wind turbines will not be visible but rather an illustration that the wind turbines will often appear blurred and will not consistently be recognised as wind turbines. See figures 5-4 and 5-5, which illustrate the difference in how clearly wind turbines appear with good and moderate visibility, respectively.

Due to the air's moisture content, an object's visibility is reduced. The contrast effect of an object relative to the background decreases as the distance to the object increases. Based on a situation where the object at close range has a 100% contrast to the environment, the contrast effect at 55 km will be reduced so much (less than 5%) that the eye can no longer distinguish the object from the background. These situations can occur in direct backlight where the wind turbines form a silhouette against the environment and in direct backlight against a dark sky.

Under other lighting conditions, the contrast is less, and thus the visibility is also less. The wind turbines have a light grey colour, and the difference to the background is therefore low, and the visibility will consequently be reduced even in cases of high visibility. However, it cannot be ruled out that the wind turbines will have special conditions with 100% contrast to the background and thus can be experienced with maximum visibility (BIRK NIELSEN, 2007).

Figure 5-4 Example of maximum visibility of wind turbines placed 15 km from the observer's position. The outline of the turbines appears as distinct objects.

Figure 5-5 Example of moderate visibility of wind turbines placed 15 km from the observer's position. The outline of the turbines appears dimmed and appears as indistinct objects.

5.3 Number and the size of the wind turbines

The theoretical visibility of the OWF is influenced by the number and size of the individual wind turbines within the planning area.

With the realisation of a maximum production capacity of 3.2 GW, the OFW will contain:

- 214 wind turbines of 15 MW with a total height of 263 m or
- 119 wind turbines of 27 MW with a total height of 330 m

With the realisation of a maximum production capacity of 3.8 GW, the OFW will contain:

- 254 wind turbines of 15 MW with a total height of 263 m or
- 141 wind turbines of 27 MW with a total height of 330 m

A high number of turbines in width affect a more significant part of the field of view, while an increased number of turbines in depth enhance the visibility of the entire wind farm, where the turbines will stand behind each other in groups and appear more prominent than a single turbine.

The height of the wind turbines influences how much is hidden behind the horizon. There are no shielding elements at sea, but a larger wind turbine is visible over greater distances than a smaller wind turbine.

The distance from the coast to the planned area means that a 15 MW turbine (total height 263 m) will be visible from the western coast of Bornholm and partly hidden behind the horizon from coastal stretches from Sweden and Germany. On the other hand, a 27 MW turbine (total height of 330 m) will be more visible, but the number of turbines will be less.

5.4 Park layouts

The visibility assessment is based on the park layouts shown in Figures 5-6. The figure shows four examples of the maximum utilisation of the planned area with resp. 119 turbines of 27 MW turbines, 214 turbines of 15 MW, 141 turbines of 27 MW, and 254 turbines of 15 MW.

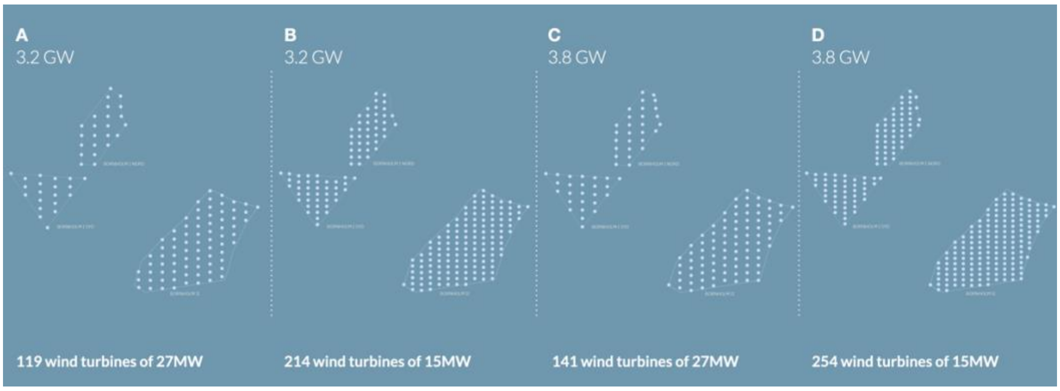

Figure 5-6 Illustrations of the park layouts used as input to the visibility assessment for both the theoretical visibility and, for example visualisation.

Different layout patterns have not been assessed. This is justified by a desire to show the visibility of the OWF at a maximum production capacity of 3.2 – 3.8 GW. This means that turbines must be evenly distributed within the planning area when placed at the recommended mutual distance to their total height and rotor diameter. Thereby, the possibilities for variations in the layout will be limited. Assessment of the layout will only be relevant in connection with an evaluation at a specific project stage. When an OWF developer is selected, and project design is decided, visualisations for the chosen park layout will be conducted as part of EIA.

5.5 Rotor movement and direction

In general, moving elements are more visible than stationary elements. However, visibility also depends on movement speed, as fast movements are captured by sight differently than slow movements.

The wind direction and, thus, the position of the rotor is also essential for the visibility of the wind turbines. Where the wind direction causes the rotor to face directly towards the viewer, the wind turbine is perceived as more visible than wind turbines, where the viewer looks along with the rotor and therefore does not perceive the horizontal extension of the turbine.

5.6 Zone of visual influence analysis - ZVI

A ZVI analysis is a calculation that indicates the visibility of wind turbines from the surrounding landscape. The calculation can be performed in have been made in WindPRO (a software that uses a mix of CAD and GIS software functions). The measure is based on a digital elevation model, and the analysis also considers the earth's curvature. The analysis can provide a theoretical chart of where the wind turbines are visible and can be detailed with how large a part of the wind turbine is visible (e.g., hub, blades, etc.).

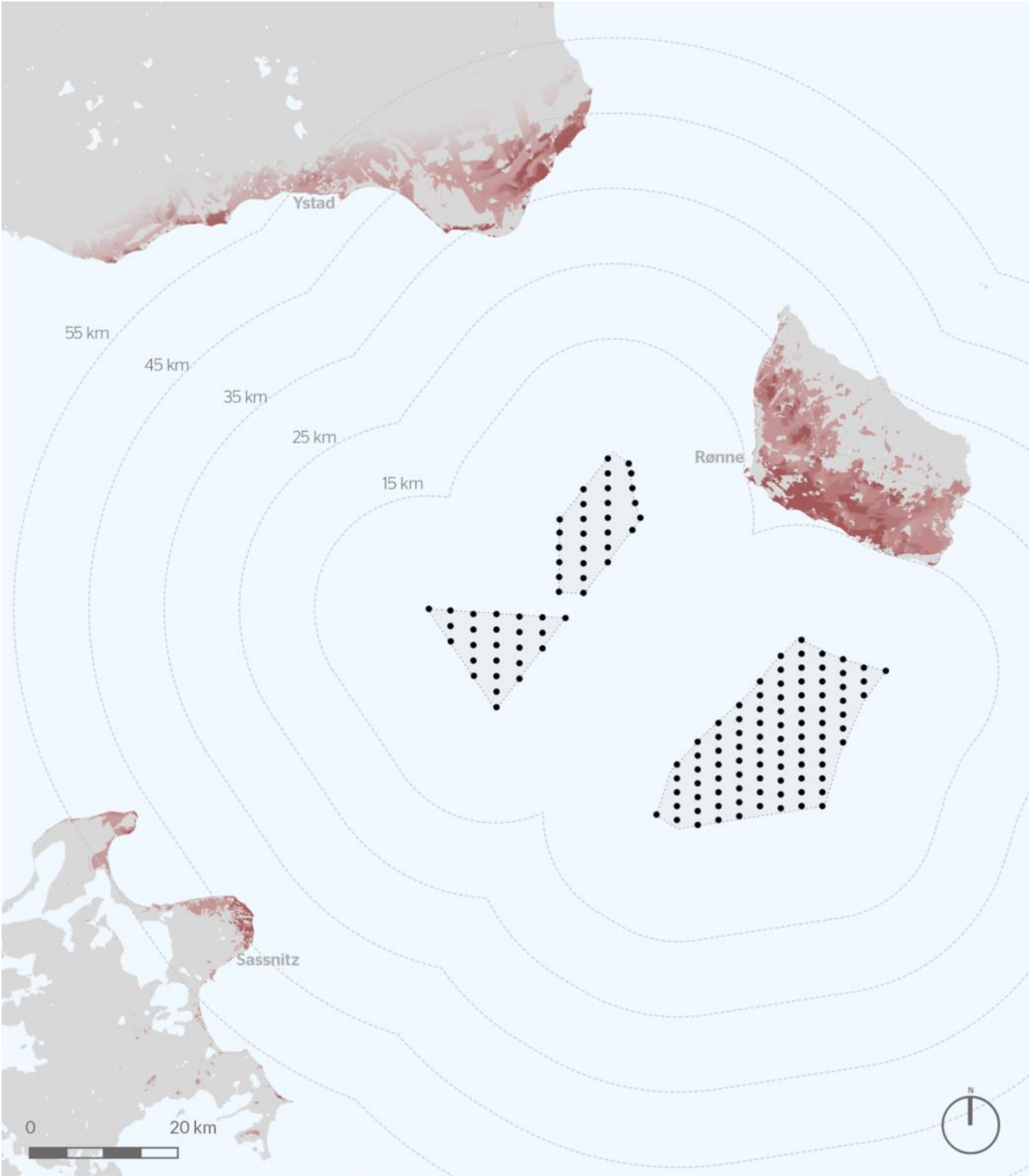

Figure 55-77ZVI calculation of maximum park layout with 141 wind turbines of 27 MW.

The image is an overlaid ZVI calculation that has been carried out to map the extraction of the zones on land that can be visually affected by the wind turbines if they are set up, as shown in park layout C. The calculation shows the theoretical visibility of 141 offshore wind turbines based on terrain conditions and the earth's curvature, but without regard to weather conditions. Areas, where wind turbines will be visible, are shown with red surfaces. Dark red means that many wind turbines will be visible, while a light red cover illustrates that a low number of wind turbines will be visible.

The ZVI calculation shows that from areas along coastal stretches, it will be possible to experience wind turbines from both Bornholm, southern Sweden, and Rugen in Germany. From Bornholm, there are large areas from the hinterland from which wind turbines can also be experienced.

The calculation is based on whether the viewer can see the hub of a wind turbine from eye level. Wind turbine geometry: Rotor diameter 300 m. Hub height 180 m. Tip height 330 m.

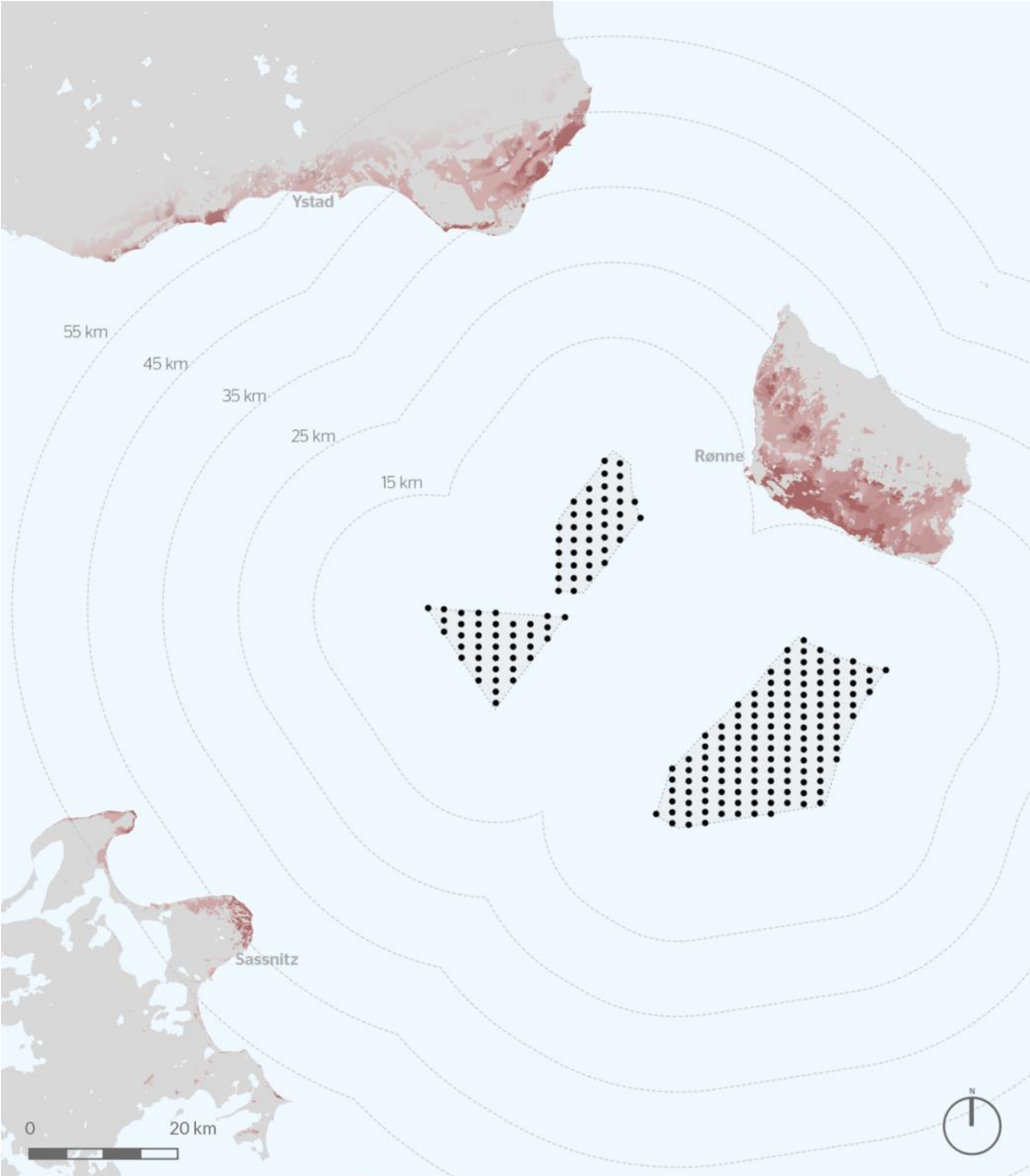

Figure 5-8 ZVI calculation of minimum park layout with 214 wind turbines of 15 MW.

The image is an extraction of a so-called ZVI calculation that has been carried out to map the extraction of the zones on land that can be visually affected by the wind turbines if they are set up, as shown in park layout B. The calculation shows the theoretical visibility of 214 offshore wind turbines based on terrain conditions and the earth's s curvature but without regard to visibility conditions. Areas, where wind turbines will be visible, are shown with red surfaces. Dark red means that many wind turbines will be visible, while a light red cover means a low number of wind turbines will be visible.

The ZVI calculation shows that from areas along coastal stretches, it will be possible to experience wind turbines from both Bornholm, southern Sweden, and Rugen in Germany. From

Bornholm, there are large areas from the hinterland from which wind turbines can also be experienced.

The calculation is based on whether the viewer can see the hub of a wind turbine from eye level. Wind turbine geometry: Rotor diameter 233 m. Hub height 146.5 m. Tip height 263 m.

6 Visual representation of the OWF

Visualisations are often perceived as very concrete as the visualised project depicts exact turbine types, numbers, locations, and photos taken from a specific point in the landscape. Therefore, visualisations are a very suitable tool for assessing the visual impact that a wind farm can inflict on a landscape or an experience of the coast and the sea. However, visualisations can also be used in visibility assessment, which is more about visibility than visual impact. In connection with the visibility assessment, visualisations have been prepared that are illustrated under different weather conditions and times of the day, as well as from various locations in the landscape. The visualisations are summarised in Appendix 1. The appendix includes the method for selecting photo points and preparing visualisations and an introduction to how the visualisations are to be read.

6.1 Visualisations

In the example visualisations, the parameters of theoretical visibility are illustrated as a visual representation of the OWF. The visualisations show the four different park layouts. In this way, the number of turbines and the turbines' size illustrate the importance of visibility.

In the visualisations, the visibility of the different layouts is illustrated under different weather conditions. The offshore wind turbines are rendered at very good visibility of over 19 km. In addition, offshore turbines are shown in weather conditions that provide moderate visibility. Based on the visibility statistics in Figure 5-4, it turns out to be the type of visibility that, on average, is most common in the Baltic Sea over the year.

In the visualisations, the offshore wind turbines are shown correctly to the earth's curvature so that only parts of the wind turbines that will be visible above the horizon are rendered.

For each viewpoint, a dotted line outlines the maximum extent of the area potentially occupied by wind turbines for Bornholm I Syd and Nord, and Bornholm II.

6.2 Selected viewpoints

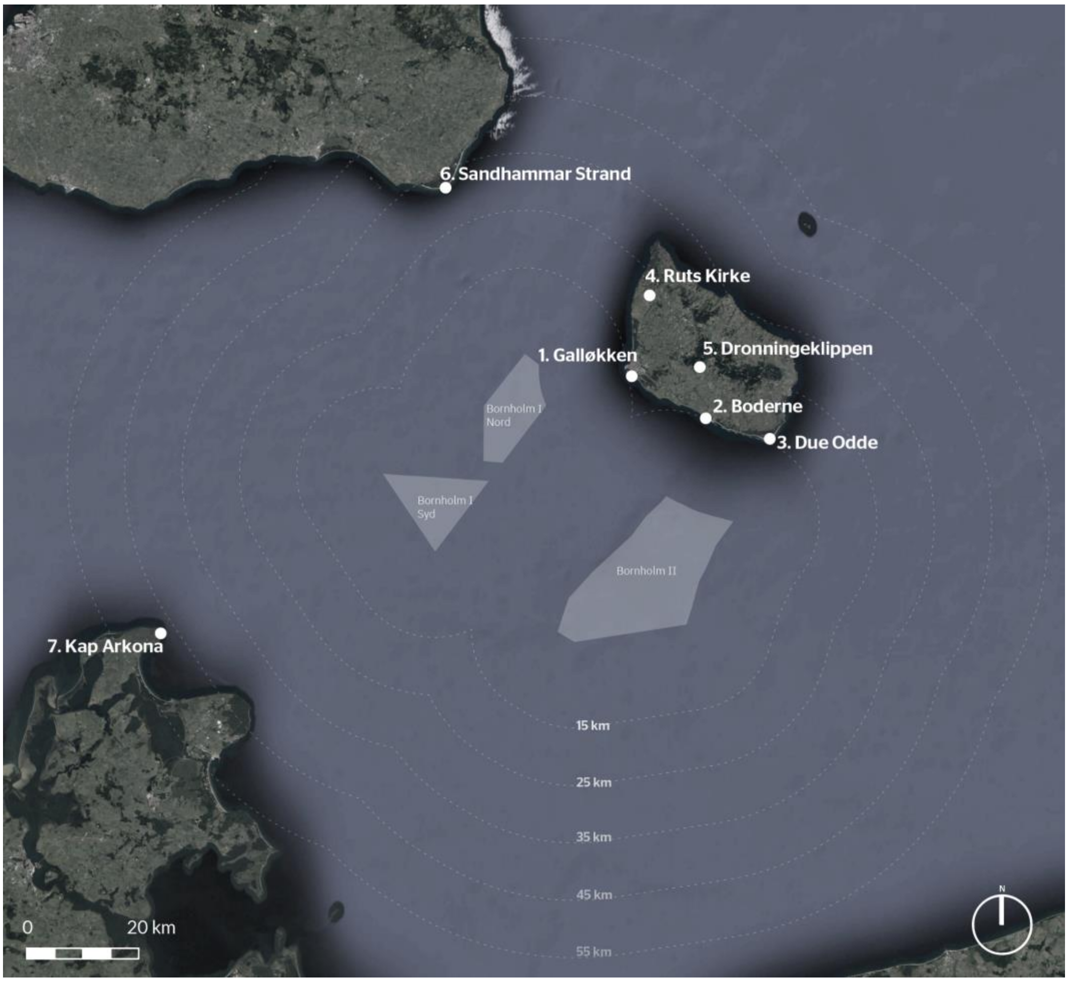

Figure 6 -1Selected viewpoints used, as example visualisations

To illustrate the maximum expected visibility of the OWF described in the Plan for Programme Energy Island Bornholm, site-specific photos have been taken from selected viewpoints along the coastal areas of Denmark, Sweden, and Germany, which have then been used for preparing example visualisations (see appendix 1).

A total of seven viewpoints have been selected (see figure 6-1). Three of the viewpoints are located along the coast of Bornholm. The viewpoints are distributed to illustrate the wind farm from the northern and southern parts of the coast and are approximately in the middle of the study area. Viewpoints 4 and 5 have been chosen so that they can illustrate the visual impact experienced from the hinterland. Viewpoints 6 and 7 show visual conditions from along the coast, as seen in Sweden and Germany.

From all viewpoints, the OWF is illustrated in daylight with maximum visibility (above 19 km). From viewpoint 1, the OWF is also presented in dim light and night with the standard light marking requirements.

Bornholms Regionskommune (the municipality of Bornholm) has provided their input to the selection of viewpoints, including additional suggestions they wish to have included for the visualisations relating to the environmental impact assessment of a future concrete project. All viewpoints are outlined below in table 6-1.

Selected viewpoints	Scenario A (3.2 GW)	Scenario B (3.2 GW)	Scenario C (3.8 GW)	Scenario D (3.8 GW)
1. Galløkken	X	X	X	X
2. Boderne	X	X	X	X
3. Due Odde	X	X	X	X
4. Ruts Kirke	X	X	X	X
5. Dronningeklippen	X	X	X	X
Deselected viewpoints				
Kaolinsøen	-	-	-	-
Tassevej	-	-	-	-
Klintebakken	-	-	-	-
Restaurant Kadeau	-	-	-	-
Arnager	-	-	-	-
Slusegård	-	-	-	-

Table 6-1 showing selected and rejected viewpoints

The visualisations have been rendered on site-specific photos. Still, the viewpoints have been chosen to best illustrate the general visibility from the coastal areas of Bornholm, Sweden, and Germany, as well as from the hinterland of Bornholm.

6.3 Appearance and lighting

The colour of the wind turbines affects the visibility. Neutral colours such as white help the turbines blend in, especially on cloudy days.

Where the wind turbines will be visible, they are rendered with a light/grey colour and only the visible parts are shown in the visualisation.

To compare the effect of the four scenarios' variation in density and volume, the visualisations have been deliberately prepared so that the wind turbines appear more clearly than they can be experienced. This is done by altering the contrast between the wind turbines and the background and leaving out the faded visibility of the wind turbines over the distance.

After sunset, it will be the light markings of the offshore wind turbines that have an impact on visibility.

The wind turbines are expected to be marked with lighting due to Aviation Safety and Maritime safety of navigation. Light may be turned on permanently after sunset or on demand when an aircraft or vessel is detected. For the visibility assessment, it is assumed that all wind turbines will be marked with the light on top of the nacelle (visible horizontally 360 degrees), (Danish Transport Authority, 2014): Day - white flashing light of 20,000 candelas, night - red flashing light of 2,000 candelas. Light markings in the middle of the tower: Three red lights with the intensity of 32 candelas. Markings, according to maritime safety, include light markings placed 15 m above MSL (mean sea level). The lighting towards the shore will be yellow lights

Provisions for light marking of offshore wind turbines due to sailing safety are set by the Danish Maritime Authority and mirrors the international IALA guideline (IALA, 2021).

Provisions for light markings of offshore wind turbines due to aviation safety are set by the Danish Transport Authority (Danish Transport Authority, 2014). The existing provision are applicable for turbines where the maximum tip height of wing position (total height) does not exceed the position of light marking on top of the nacelle with more than 120 m, and a revision of the provisions to better suit turbines where this maximum distance of 120 m is exceeded is therefore expected before 2030.

Visualisations have been carried out in dim light and at night-time, showing the maximum intensity of the light markings for both Aviation Safety and Sailing Safety.

The rendering of the light markings on the wind turbines cannot reproduce flashing lights. Light markings have been rendered in front of the turbines in the visualisations to show the maximum intensity to represent "worst case".

Figure 6-2 shows the intensity and placement of the light markings.

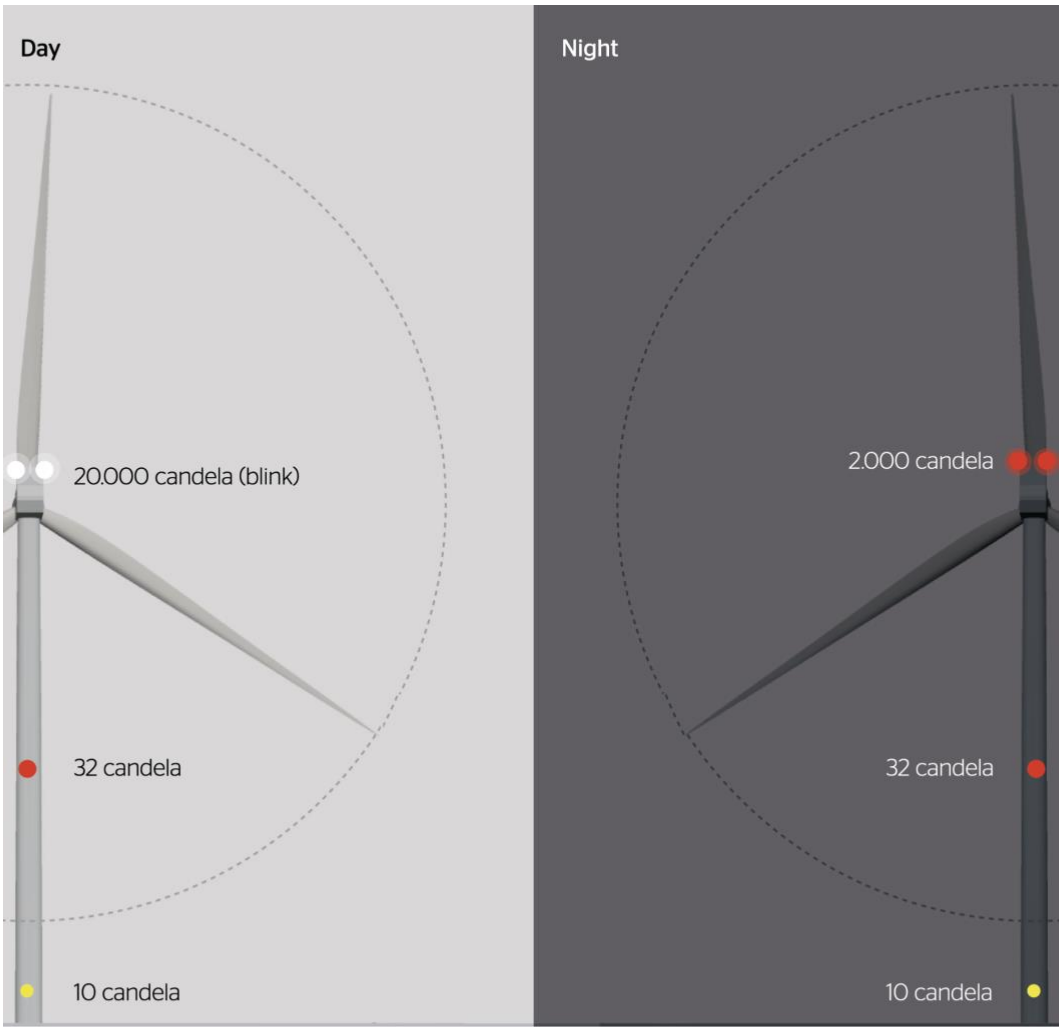

Figure 6 -2 Light markings of the offshore wind turbines, day and night.

7 Cumulative impacts

In addition to the OWF of Plan for Programme Energy Island Bornholm, there are both existing offshore wind farms and ongoing planning and construction from several other offshore wind farms in the Baltic Sea.

To illustrate a potential visual, cumulative effect between OWF of Plan for Programme Energy Island Bornholm and other offshore wind farms (existing, under construction or currently in development), the example visualisations have been prepared to illustrate the cumulative conditions.

Figure 7.1 Selected viewpoints used as example visualisations and OWFs that provide cumulative conditions

The map in Figure 7.1 shows the projects that are part of the visualisation of cumulative conditions: existing, under construction and planned wind farms Arkona, Wikinger, Arcadis Ost1 and Baltic Eagle.

The cumulative conditions are included in visualisations from all viewpoints.

Though limited, possible cumulative effects will be from Bornholm and Germany, where wind turbines will take up a considerable part of the horizon. No cumulative impacts are expected from the coast of Sweden.

8 References

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