# Horns Rev Offshore Wind Farm

## Environmental Impact Assessment
## Summary of EIA Report

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# 1. Project background

The Danish Government's energy action plan "Energy 21" sets as a goal that renewable energy is to cover 12-14% of the total Danish energy consumption. The goal for the period 2005 to 2030 is to achieve an annual increase of 1 percentage-point in the share of renewable energy in the Danish energy system This means that the total share of renewable energy will be approximately 35% in 2030. In order to achieve this long-term expansion, a significant increase of offshore wind farms is expected – by up to 4,000 MW in 2030.

The purpose of increasing the share of renewable energy is to ensure environmental improvements and to improve supply security. The environmental improvements will, inter alia, comprise a reduction of the pollution from traditional power stations. The supply security will be improved as dependency on imported fuels is reduced.

One of the preparatory studies for "Energy 21" was a survey of the possibilities of construction of offshore wind farms. A working group under the Ministry of Environment and Energy carried out the survey. The working group evaluated a number of conditions with a view to select possible areas for location of offshore wind farms. These conditions included scenic aspects, bird sanctuaries, raw material extraction, marine archaeology, fisheries, shipping routes and military areas. Based on the above-mentioned evaluation, five areas were selected as providing the most suitable sites for extension with offshore wind farms (figure 1.1).


*Figure 1.1 Main areas for the offshore wind turbines.*

In February 1998, as a step towards the fulfilment of the goal of “Energy 21”, the Minister of Environment and Energy ordered I/S Elsam and Eltra amba to jointly erect two offshore wind farms of up to 150 MW each. The offshore wind farms were to be established as large-scale demonstration facilities at the investigated sites at Horns Rev and south of Læsø.

This environmental impact assessment concerns the facility at Horns Rev. The issues discussed in this summary are described in more detail in the actual EIA report and in a number of technical background reports.

# 2. Description of the offshore wind farm

The offshore wind farm applied for is located south of Horns Rev. The distance from the north-easternmost turbine to Blåvands Huk is approximately 14 km.


*Figure 2.1 Location of offshore wind farm and cable to shore. The substation is located at the T.*

The offshore wind farm consists of the following three main components:

**The wind turbines**
Up to 80 wind turbines will be placed in a grid pattern. The distance between the individual turbines and the lines is 560 m.

**Cables internally in the offshore wind farm and substation**
A 36 kV cable net interconnects the turbines. In the northeastern part of the offshore wind farm, a substation is established to which the cables are connected.

**Cables to shore**
A 150 kV submarine cable and land cable connects the substation to the overall grid onshore.
Each of the main components is described in more detail in the following sections.

## 2.1 The wind turbines

To ensure that the offshore wind farm will constitute a harmonic unity, the turbines are to comply with the following criteria:

- The tower must be a tubular tower;
- The direction of rotation is to be clockwise seen from the windward side;
- The hub height is to be between 60 and 70 m;
- The rotor diameter is to be between 66 and 80 m;
- All turbines must have the same colour (navy grey colour); and
- The turbines must be upwind turbines (the rotor facing the wind) with three-bladed rotors.

The maximum height to the tip of the upper blade will be 110 m. The type of turbine is illustrated in figure 2.2.

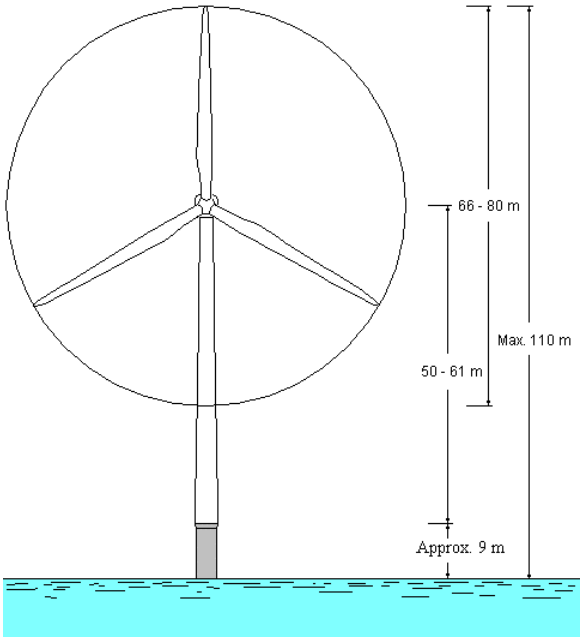


*Figure 2.2 Turbine dimensions.*

The final number of turbines still remains to be determined. The turbines will have a minimum electrical output of 1.8 MW. This size will call for erection of 80 turbines. If the turbines feature an output higher than 1.8 MW, the number of turbines will be reduced to achieve a total output of the wind farm of approx. 150 MW. The wind turbines will be placed in a grid pattern, which gives the best utilisation of the wind while at the same time offering the most harmonic visual impression.

The turbines are to be secured in the seabed on a foundation. A variety of solutions have been considered, but it is expected that the foundation will be a so-called “mono-pile”, i.e. a steel pipe which will be driven into the seabed. The diameter of the monopile is expected to be between 3.4 and 4.0 m and the monopile will be driven up to 25 m into

the seabed. The connection between the turbine and the foundation will be approx. 9 m above the surface of the water. At this level there will be a platform.

To avoid scouring of the bottom material around the foundation due to the strong current at the site, it will probably be necessary to protect the foundation either with a rubble mound or with a concrete cone. (figure 2.3).

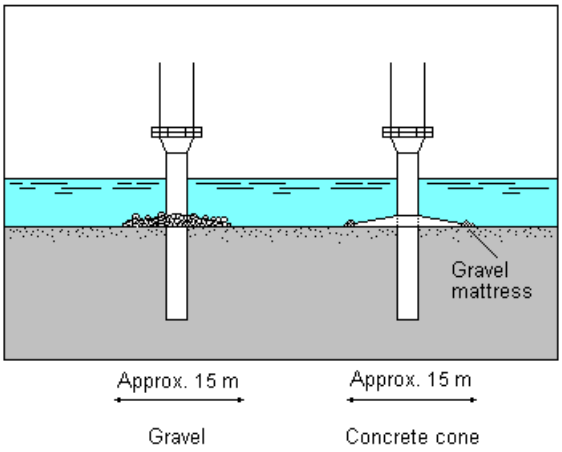


Figure 2.3 Foundation with protection at the foot.

The wind turbines are to be marked with lights in consideration of sea and air traffic.

The wind turbines are to be corrosion ("rust") protected. This will be done by a combination of methods, such as, paint and possibly rubber covering.

When the construction of the offshore wind farm is to take place, the main components will be prepared onshore and transported to the site. The foundations will be driven into the seabed by a pile driver placed on a platform or on a barge. To the extent possible the turbines will be assembled onshore. For some types of turbines, it is possible that the entire turbine will be transported to the site and erected on the foundation. It is expected that the total construction period for foundations, turbines and cables will be around 6 months in the summer of 2002.

During normal operation the offshore wind farm will in principle be unmanned. However, each turbine must be inspected and serviced approx. twice a year, and in addition service due to malfunctions may be required. In practice it should be expected that the offshore wind farm is manned approx. 150 days a year. Due to the difficult access conditions from the sea, it is expected that many service tasks will have to be effected by lowering the service personnel to the turbine from a helicopter. Other service inspections will be made by ship.

The exact type of turbine and foundation to be used in the project has not yet been determined. Tenders will be invited in which turbine manufacturers may suggest preferred solutions. This may cause changes in the details of the project. However, the overall philosophy will be as described above.

## 2.2 Cables in the offshore wind farm and the substation

Cables (36 kV) in lines in north south direction will interconnect the wind turbines. All cables are connected to a substation located northeast of the offshore wind farm.

The energy produced in the wind farm is collected in the substation and transmitted to the shore via a cable connection. The substation is also to function as a helipad and as crew's quarters in connection with servicing of the wind farm.

The substation is to be placed on three foundation piles each with a diameter of 1-2 m. The platform will consist of a steel structure of approx. $20 \times 28$ m, which will be placed approx. 14 m above the sea surface and with a building height of approx. 7 m.

The cables in the wind farm can be laid from a cable ship. The cables will be fixed to the seabed or embedded using water jetting approx. 1 m into the seabed. The foundation piles of the substation will be driven into the seabed in the same way as the turbine foundations. The actual substation will be assembled onshore and transferred on a barge to the wind farm where it will be lifted into place by a floating crane.

## 2.3 Cable to shore

The submarine cable transfers the energy produced in the wind farm to the transmission grid ashore. The cable starts from the substation and ends either at Hvidbjerg Strand (owner's – Eltra – suggestion) or at Sædding Strand (please see the later discussion of the alternatives). The submarine cable is a 150 kV cable, which is to be water jetted approx. 1 m into the seabed to protect it from being damaged by fishing tackles and small anchors. The distance from the offshore wind farm to Hvidbjerg Strand is 19.5 km, whereas the distance to Sædding Strand is 36 km.

It is possible to chose between different cable types, but the final decision has not been made yet.

As the cable is to be laid by a cable ship, a water depth of at least 4 m is required. The cable laying must take place in calm weather, but it only requires two efficient working days. The alternative route to Sædding Strand will require a longer working procedure, as it will have to be laid across areas with shallow water. After the cable has been laid, it is water jetted into the seabed.

A cable protection zone of 200 m will be established around the wind farm and the cable, and within this zone anchoring and fishing will not be allowed.

# 3. Alternative sites and landing points

During the planning of the offshore wind farm project, a number of alternatives have been considered for the proposed project. These alternatives concern an alternative site for the wind farm as well as alternative routes for the submarine cable.

## 3.1 Site of the offshore wind farm

The first question to be asked is: What are the consequences of not establishing an offshore wind farm at Horns Rev at all? The answer to this question will have to be based on the fact that the objectives of the Danish energy and environmental policy, as expressed in “Energy 21”, are to be fulfilled even if an offshore wind farm is not established at Horns Rev. As described above, the objective of “Energy 21” is that 12-14% of the total energy consumption is to be covered by renewable energy. On this background the conclusion is that the alternative to establishing an offshore wind farm at Horns Rev would be to establish a larger wind farm south of Læsø. None of the other renewable energy technologies can be further pushed in their development. Taking into account that the offshore wind farm at Horns Rev is a demo-plant to be used to evaluate the possibilities of extensive expansion of offshore wind farms in Denmark, the same value of demonstration would not be gained from establishing one large offshore wind farm instead of two.

For the location of the offshore wind farm at Horns Rev, two different sites have been evaluated (figure 3.1). The alternative site has primarily been chosen to evaluate the possibilities of placing the wind turbines at a distance where they are no longer visible from the shore, i.e. more than 25 km from the shore. At the same time it has to be a site with a maximum water depth of 15 m. For technical reasons, wind turbines cannot be established directly on the reef.

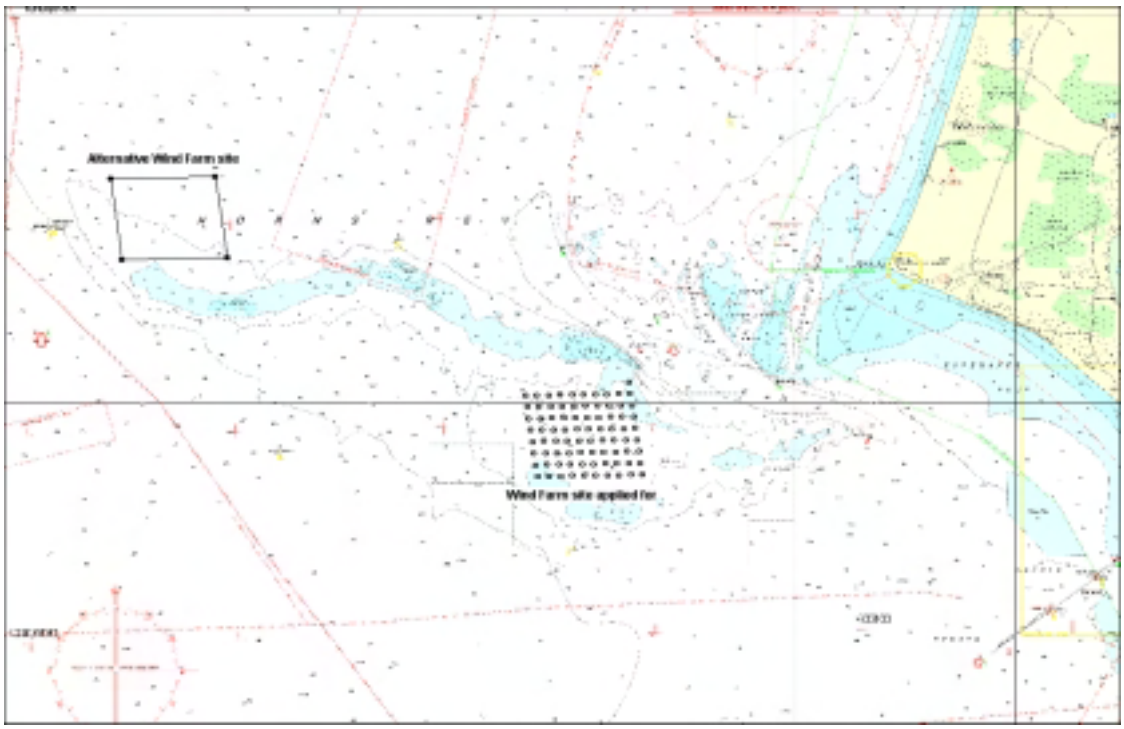


*Figure 3.1 Alternative offshore wind farm site.*

When comparing the two possible sites for the offshore wind farm, the site applied for is by far the most favourable alternative. Summaries of the arguments against the alternative site are as follows:

- **Technology:** As Horns Rev does not provide any shelter from waves from north-west, a stronger foundation and as such heavier foundation laying is necessary.

- **Transport/operation:** The long distance to shore results in longer transport time and increased use of helicopters. The difficult access conditions may result in longer time spent on repairs and consequently less energy production.

- **Fishing:** The submarine cable will be longer and therefore of more inconvenience to the fishing industry.

- **Economy:** Increase of construction and operating costs and loss of income due to a smaller energy production. The additional construction costs alone are estimated to amount to DKK 170 million.

The conclusion is that the visual conditions would be improved at the expense of a number of conditions relative to technology, transport and operation, fishing and economy. These are the reasons why the site closer to the shore has been selected.

## 3.2 Alternative cable routes for the submarine cable

A number of alternative routes for the submarine cable has been evaluated (figure 3.2).


*Figure 3.2 Alternative cable routes for submarine cable to shore.*

The arguments relative to the individual alternatives are listed in the below table.

| Alternative | Arguments in favour | Arguments against |
|---|---|---|
| 1: Blåvands Huk | Limited impact on the flora and fauna<br>Short cable route<br>Limited inconvenience to fishing and shipping | Hydrographically unstable<br>Military interests in the area |
| 2: Hvidbjerg Strand | Limited impact on flora and fauna<br>Short cable route<br>Unproblematic cable laying<br>Limited inconvenience to fishing and shipping | Withdrawal of coast line<br>Risk of exposing the cable on the beach |
| 3: Esbjerg north of Fanø | | Long submarine cable<br>Considerable laying costs<br>Risk of considerable operating malfunctions due to cable sectioning (cable in six sections)<br>Navigation channel will have to be crossed<br>Considerable inconvenience to fishing<br>High-voltage system in urban area<br>Feasibility uncertain |
| 4: Across Fanø to Esbjerg | Hydrographically stable<br>Technically feasible | Long submarine cable.<br>Cable protection zone may hinder anchoring in the area<br>Navigation channel to Esbjerg will be crossed<br>Goes through internationally protected area – both onshore and at sea<br>Considerable inconvenience to fishing<br>High-voltage system in urban area |
| 5: Sædding Strand | | Considerable construction costs due to long submarine cable<br>Risk of operating malfunctions due to cable sectioning (cable in two sections)<br>Navigation channel will be blocked during construction<br>Considerable inconvenience to fishing<br>Extension with high-voltage system in urban area<br>Feasibility uncertain |

The investigations conclude that a submarine cable laid to Hvidbjerg Strand would cause the fewest problems in terms of environment, laying technique and economy. This is therefore the main suggestion and the route has been subject to an EIA review. As an alternative, a cable laid to Sædding Strand is considered in more detail.

# 4. Description of the area at Horns Rev

To be able to evaluate the possible environmental impact of the offshore wind farm a number of investigations of the conditions at Horns Rev have been made. The results of

the investigations are described in detail in the actual EIA report as well as in a number of technical background reports. The next section describes the area of the offshore wind farm applied for and the cable route to shore. Section 5 includes an evaluation of the environmental impact of the installations.

## 4.1 Physical aspects

Horns Rev, which is an area with relatively shallow water, stretches from Blåvands Huk westwards into the North Sea. The reef itself consists of sand, gravel, pebbles and boulders with a few pockets of fine-grained material. The sand layer on the seabed is 10-20 m deep in the site selected for the offshore wind farm.

Horns Rev forms the northern boundary of the area, which is influenced by the flow of freshwater from the German rivers. This means that the salinity of the water varies but is slightly lower than in the open part of the North Sea. The content of nutritive salts, however, is higher than it is in the open sea areas.

There is a lot of wind in the area – predominantly from the west. The average wind speed is 10 m/s. This causes the water to be stirred and prevents layering or oxygen depletion in the area. At the same time the winds and currents cause shifting of the materials on the seabed. Considerable sand drifting along the sea floor has been noted.

## 4.2 Biological aspects

The seabed of the offshore wind farm site is characterised by sparse fauna and flora. No plants are growing on the seabed of the site. The fauna in the seabed is similar to other areas with sand seabed in the North Sea. There is a relatively low number of species and members of species. The sparse fauna on the seabed is related to the frequent rebedding of the seabed material.

Existing studies of the fishes only allow for evaluation of an area considerably larger than the offshore wind farm site. The conclusion is that the fish populations vary greatly from one year to the next. The common shrimp is only moderately represented at the offshore wind farm site, more are found in the area closer to the coast.

Blåvands Huk is known all over the country as a bird watching site, and the Wadden Sea is an important breeding and resting area for birds. However, surveys made by plane and ship show that the birds are closer to the shore than to the offshore wind farm site applied for. For example, registrations made in the coastal area from November to March show quite a number of common scoters close to the coast. The tendency is that there are fewer birds at the proposed offshore wind farm site than in the adjoining sea areas.

Dense populations of the common porpoise are found north-east of the proposed offshore wind farm area in deep waters named “Slugen”, whereas only few porpoises have been observed at the actual offshore wind farm site. At the western part of Horns Rev, approx. 15 km from the offshore wind farm site, porpoises with calves have been ob-

served during two summer registrations. The occurrence of seals is very sparse at Horns Rev.

## 4.3 Human activities

Many recreational activities take place along the West Coast of Jutland, not least in the area of Blåvands Huk and on Fanø where there are large areas with good bathing beaches and many tourists who seek the magnificent view over the North Sea. Tourism is therefore the predominant source of income on Fanø and in the municipality of Blåvand. To protect the most important natural interests, a number of preservation regulations as well as other protective measures have been set up in the coastal areas.

There are several types of fishery in the area around Horns Rev, the predominant type is trawling for sand launce and sprat. There is also some net fishing for flatfish. A type of mussel, thick-shelled trough mussel, has previously been fished at the offshore wind farm site, but this species suddenly disappeared in 1995.

Besides the fishing boats there is some shipping in the area around Horns Rev. However, the shipping routes lead around the areas of shallow water where it is proposed that the offshore wind farm be established.

Sites designated for raw material extraction are located south of the offshore wind farm. The last few years have seen a decline in the extraction of raw materials, but the areas as such would not be affected by the construction of the offshore wind farm.

The site planned for the offshore wind farm has been surveyed to locate any wrecks or other items of archaeological interest. None have been found, but during the construction work, attention will be given to the possibility of making archaeological finds.

# 5. Environmental consequences of the offshore wind farm

A number of possible environmental consequences of establishing the proposed offshore wind farm at Horns Rev have been reviewed in the EIA report. The conclusions of the evaluations are briefly summarised below.

## 5.1 Physical aspects

The construction works in connection with the establishment of the offshore wind farm and the cable connection to shore will have an impact on the seabed. This will partly be in relation to the location of the foundations for the turbines and the substation and partly by water jetting the cables. For both activities, model calculations and evaluations show that even in a worst-case scenario the impact on the environment on the seabed will be minimal compared to the shifting which takes place naturally.

When the offshore wind farm has been established, the foundations will cover parts of the seabed but they will also provide a new habitat for fauna and flora. The foundations including scour protection will cover approx. 14,500 $m^2$, whereas the new surface on the actual foundations will be approx. ca. 12.000 $m^2$. However, these effects are both minimal. The area, where the offshore wind farm is to be erected, covers a total of 27.5 $km^2$. The impact on the altered habitats is in the range of 0.5‰ of the area of the offshore wind farm.

The location of the foundations of the wind turbines will affect the currents in their immediate vicinity. However, the effects will only be of a very local nature. Model calculations show that the total current velocity is reduced by 2% at the most before and after the establishment of the offshore wind farm. The current across Horns Rev is not critical to the water quality in the adjacent sea areas.

During the establishment and maintenance of the offshore wind farm there will be some transport by ship and helicopter to the offshore wind farm site. This may cause air pollution by, inter alia, $CO_2$ and $NO_x$. However, the transport to the offshore wind farm constitutes only an insignificant part of the existing transport in the area.

There are a number of risks of oil spillage in connection with the operation of the offshore wind farm. Accidents may happen to the turbines or the substation. There is a small risk that ships run into the foundations and subsequently cause oil pollution. And finally, anchoring ships may rip over cables and thereby release part of any oil which may be in the cables. Considered separately, the mentioned accidents will only cause very limited oil spillage. As the risk of the accidents happening at all is very little, oil pollution is not a serious risk of the offshore wind farm.

## 5.2 Biological aspects

Beforehand, the most serious biological concern of an offshore wind farm at Horns Rev was the possible impact on the large bird migrations along the West Coast of Jutland – not least around Blåvands Huk. Mapping of the distribution of the birds, however, (as referred in section 4.2) showed that the distribution of birds in the area where the offshore wind farm is suggested is very limited. On the basis of the mapping of the distribution of the birds and based on background knowledge of their behaviour, it is estimated that the largest risk for the birds would be to collide with turbine blades when chasing shoals of fish. This may refer to the species terns, arctic skuas and gannets, but would not, however, have any influence on the total population of these three species.

Due to the physical conditions there is only a sparse fauna and flora in the seabed of the offshore wind farm site. As discussed in section 5.1, there will only be a very limited reduction of the seabed area used by animals and plants. The total loss of habitat would affect less than 0.1% of the bottom fauna within the site. Furthermore, observations of the foundation of the established meteorological mast in the area have shown that new flora and fauna communities are established on the foundation. Observations further show that sand stirred up in storms practically scrubs the foundation clean of animals and plants. Thus fouling on the foundations is not expected to develop much.

The offshore wind farm may influence the distribution of fish in the area in different ways. As it appears from the previous section, the amount of feed for the fish will not be influenced to any major extent. On the contrary, experience has shown that fish – especially cod species – are attracted to physical structures on the seabed, eg. wrecks. The foundations of the offshore wind farm may attract fish. To which extent this will be, cannot be estimated in advance. Submarine noise from the turbines and electromagnetic fields from the cables may – locally – have an influence on the distribution of fish, but seen as a whole, these impacts are most likely negligible.

There are quite a lot of common porpoises in the area west of Blåvands Huk. However, the highest number of porpoises is found between the offshore wind farm and the shore. There may be a breeding area for porpoises west of the offshore wind farm. One year of investigations is not enough to determine the stability of these patterns of distribution. Even though the offshore wind farm may have a local, negative effect on the porpoise population, it will in no way threaten the distribution of the species in the North Sea. Probably, the animals will only avoid getting too close to the turbines.

## 5.3 Human activities

A number of visualisations have been prepared to show the visual appearance of the offshore wind farm from various positions onshore. The curvature of the earth means that the turbines would be impossible to see from a distance of 45 km. In practice, the visibility makes it difficult to the see the turbines at even shorter distances. The visualisation shows the offshore wind farm seen from the closest point onshore – Blåvands Huk – on a very clear day.

*Figure 5.1 Visualisation from Blåvands Huk.*

The landscape evaluation concludes: “From this position the offshore wind farm would be visible. Different weather conditions may easily diminish or hinder the visual appearance of the turbines, but on a clear day with high visibility and blue sky the wind turbines will appear as a visible element on the horizon. However, by selecting turbines of a max. height of 97-110 metres, the wind farm does not seem to dominate compared to the wide open view of sky and sea.”

There is no one conclusion as to what impact the establishment of an offshore wind farm would have on the tourism along the West Coast of Jutland. For some, this man-made element will disturb the impression of the grand nature along the coast. For others, the glimpse of one of the world’s first offshore wind farms will be an attraction in itself. Both mechanisms will probably only have limited impact since the dominance of the wind farm is so modest.

Today, there is some fishing in the area where the plan is to establish the offshore wind farm. Mostly trawling for industrially consumed fish (sand launce and sprat). These fishing activities will be affected, as trawling will not be allowed at the offshore wind farm site and in the vicinity of the cable to the shore. The area, which will be rendered inaccessible for trawling, is, however, only a very limited part of Horns Rev, but in view of a long-term extension with more wind turbines in the area, it may be of increased importance. On the other hand, the attracting effect of the foundations may provide new possibilities for net fishing in the area.

According to investigations of the noise emitted by the offshore wind farm the turbines will be heard at a distance of 1 km at the most. This means that it will be impossible to hear them onshore.

The offshore wind farm site is outside the area where sand and gravel are extracted today. The project will as such not affect the raw material extraction.

The area planned for the offshore wind farm has been examined in order to locate any wrecks or other items of archaeological interest. Nothing has been found so far, but during the construction period, attention will be given to the possibility of making archaeological findings.

## 5.4 Summary and measures to minimise the environmental impact

Establishing the proposed offshore wind farm at Horns Rev has two significant impacts.

- Under favourable weather conditions the turbines will be visible from the shore. This especially applies to areas, which are important from a tourist point of view, such as Blåvands Huk. The only way to avoid this impact is to move the turbines further from the shore. However, from the alternative site of the offshore wind farm the turbines would still be visible. The alternative offshore wind farm site is discussed in section 3.1 It is estimated that the offshore wind farm at the site applied for will not have a predominant appearance even during favourable weather conditions. A number of measures are taken to reduce the visual impact of the turbines as

much as possible the turbines: The turbines are painted a navy grey and a maximum height is set for them.

- Fishing with trawl will be prohibited within the offshore wind farm and near the cable to the shore. Economic compensation to the affected fishermen will be negotiated.

The possible impacts on birds and porpoises are still uncertain. It may be concluded with some certainty that one offshore wind farm, as applied for in this project, will not cause considerable ecological consequences neither to birds nor to porpoises. However, one of the purposes of the installation is to evaluate the possibility of further extension with offshore wind turbines at Horns Rev. Seen in this perspective, the wind farm may provide an opportunity to study the impact on the behaviour of animals and birds. An investigation will be initiated to evaluate the long-term impact on bird and marine mammals.

Other risks of pollution, eg. by oil, waste of bottom material and destruction of historical wrecks can to a wide extent be prevented by exhibiting due care in the design of the offshore wind farm and in connection with realisation of the project. As examples of the considerations which are made can be mentioned:

- The diesel tanks at the substation are to have double walls to reduce any risk of leakage.

- Wherever oil is used in the turbines and at the substation, systems are installed to collect any oil spillage.

- Waste in connection with the construction work will be collected and disposed of according to applicable rules. The same applies to waste from the crew and service module at the substation.

- The turbines will be provided with lights to reduce the risk of collision with ships and aeroplanes.

- The submarine cable to the shore will be trenched in the seabed to reduce any risk of damage resulting in oil spillage.