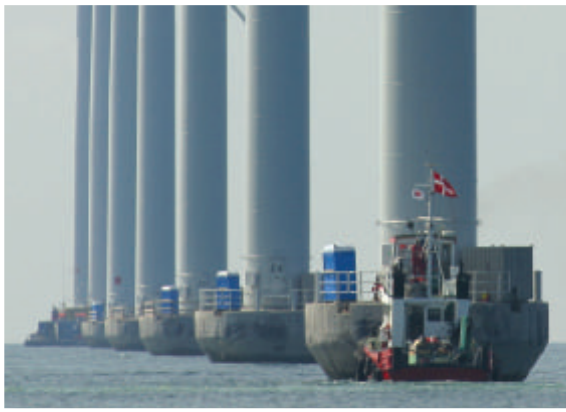
NystedHavmøllepark

The construction of Nysted Offshore Wind Farm



CONTENT

WIND ENERGY IN DENMARK

Denmark is a global leader in wind energy. So it also follows that the world's largest offshore wind farms found today are in Denmark. One is Horns Rev Offshore Wind Farm on the Jutland west coast, and the other is Nysted Offshore Wind Farm at Rødsand, 10 kilometres south of Nysted.

DONG Energy operates the Nysted Offshore Wind Farm, which is owned by a consortium consisting DONG Energy (80 %) and E.ON Sweden (20 %). SEAS-NVE Transmission owns the substation and the grid connection.

Erection of the offshore wind turbines on the foundations commenced on 10 May 2003, and the first turbine was in place the next day. Less than three months later, all turbines were up on their foundations. The last offshore wind turbine was erected on 27 July 2003, and all 72 wind turbines was thus in place. That same day, 10 of the wind turbines were already operating. The entire offshore wind farm started commercial operation on 1 December 2003.

WIND POWER IS CLEAN POWER

Denmark has set a national target for reducing its CO_2 emission. One way of lowering CO_2 emissions is to manufacture power at wind farms instead of at conventional power stations. To this end, in February 1998 former Minister for Environment and Energy, Svend Auken, required SK Power Company A/S, Copenhagen Energy and Østkraft to establish Nysted Offshore Wind Farm, then known as Rødsand Offshore Wind Farm.

Wind turbines produce renewable energy without polluting. Annually, Nysted Offshore Wind Farm at Rødsand will prevent 500,000 tonnes of CO_2, 490 tonnes of SO_2 and 440 tonnes of NO_x , which would otherwise have been emitted from existing power stations, from escaping to the environment.

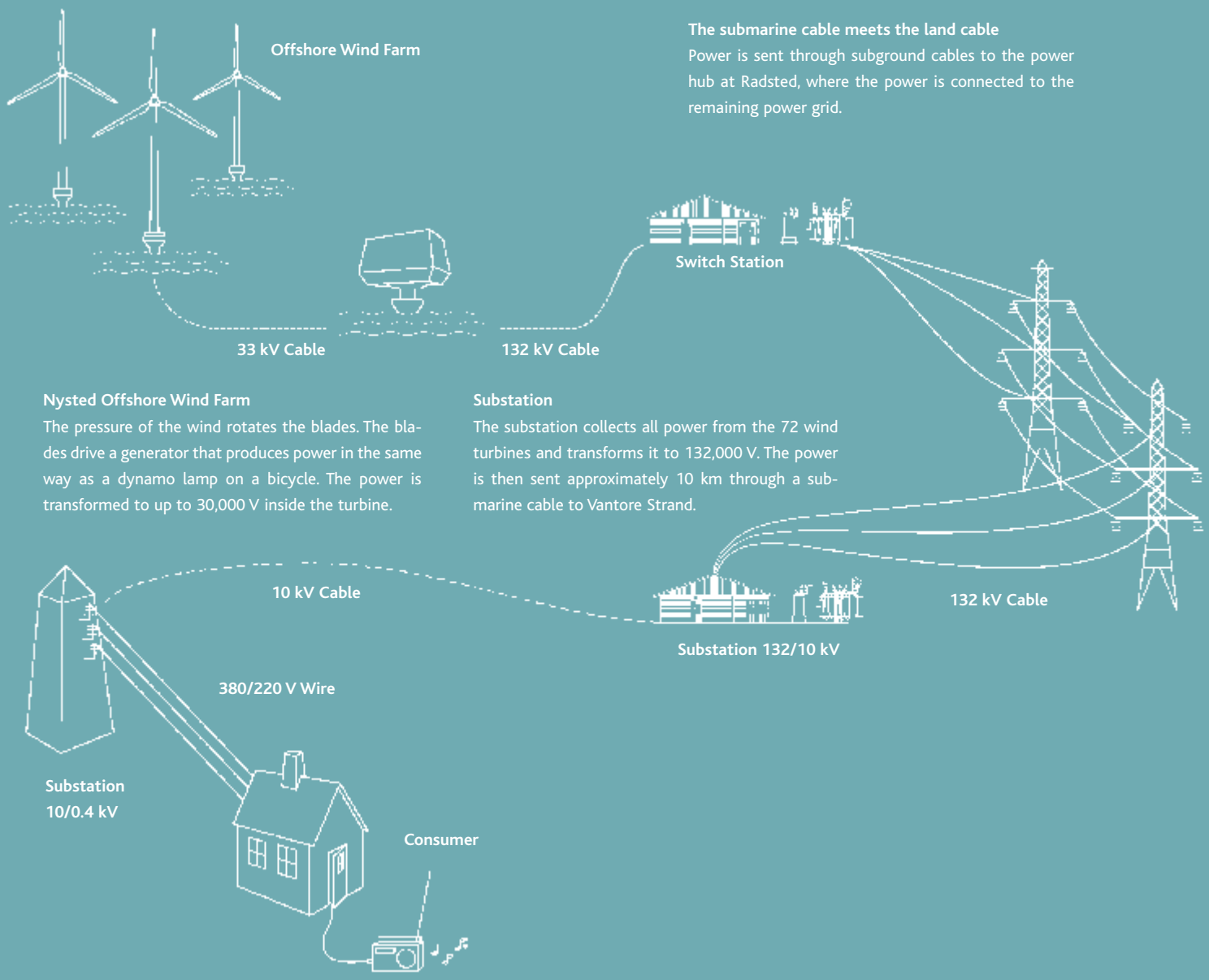
WHY OFFSHORE WIND TURBINES?

It is more demanding and considerably more expensive to place wind turbines at sea than on land. So why bother?

First of all, an offshore wind turbine on average produces 1.5 times more power than a similar land-based wind turbine - quite simply because winds are more frequent and stronger offshore.

Secondly, most of the best locations for wind turbines are already in use. Besides the need for proper wind conditions, consideration to any neighbours also limits the number of possible land-based wind turbines.

FROM WIND TURBINE TO THE OUTLET

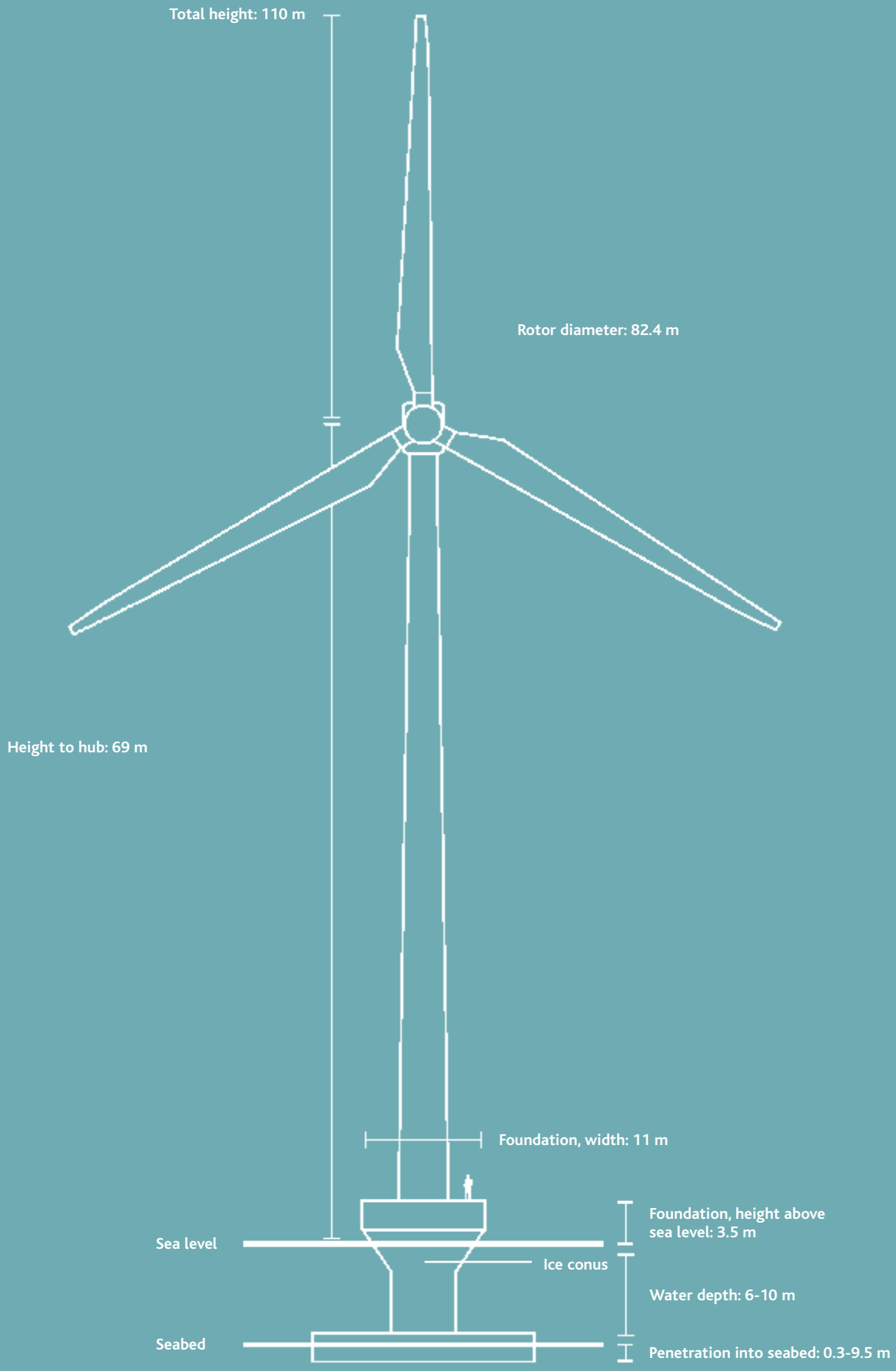


The submarine cable meets the land cable
Power is sent through subground cables to the power hub at Radsted, where the power is connected to the remaining power grid.

Nysted Offshore Wind Farm
The pressure of the wind rotates the blades. The blades drive a generator that produces power in the same way as a dynamo lamp on a bicycle. The power is transformed to up to 30,000 V inside the turbine.

Substation
The substation collects all power from the 72 wind turbines and transforms it to 132,000 V. The power is then sent approximately 10 km through a submarine cable to Vantore Strand.

WOULD YOU LIKE TO KNOW MORE?
Read about the wind turbines at www.nystedwindfarm.com


Total height: 110 m
Rotor diameter: 82.4 m
Height to hub: 69 m
Foundation, width: 11 m
Foundation, height above sea level: 3.5 m
Sea level
Ice conus
Water depth: 6-10 m
Seabed
Penetration into seabed: 0.3-9.5 m

HOW THE OFFSHORE WIND TURBINES AND THE SUBSTATION LOOK

FACTS ON THE FARM AND THE WIND TURBINES

Nysted Offshore Wind Farm at Rødsand encompasses 72 offshore wind turbines. They are placed in a parallelogram, numbering 8 rows of 9 turbines each. All the wind turbines are alike, painted in the same subtle marine-grey colour. Danish turbine producer Siemens Wind Power supplied the turbines.

TECHNICAL DATA

- Each wind turbine can produce 2.3 Megawatts. The offshore wind farm's total output reaches 165.5 MW.
- Expected annual production: 595 mill. kWh, equalling the electricity consumption of more than 145,000 single-family houses
- Hub height 69 m
- Weight, nacelle and blades: 135 tonnes
- Weight, tower: 115 tonnes
- Weight, foundation: approx. 1,800 tonnes
- Total weight of each turbine: approx. 2,050 tonnes
- Cut-in wind: 4 m/s (light breeze)
- Full production from 14 m/s (strong breeze)
- Normal wind speed at 45 m altitude at Rødsand: 12 m/s
- Cut-out wind: 25 m/s (storm)
- For flight-safety reasons, the outer 6 turbines in the farm have intensive red lights mounted on the nacelle top. The blinks are synchronised The remaining turbines constantly shine a weaker, red light.
- Closest town: Nysted (approx. 10 km)
- Offshore wind farm area: 24 km^2
- Water depth in the area: 6 -10 metres
- Placement: Eight rows of nine wind turbines
- Distance between the rows: 850 metres
- Distance between the turbines: 480 metres

SUBSTATION

- 48 km of cabling connects the offshore wind farm and the substation
- High-capacity emergency power unit
- The substation has survival rooms for technicians, intended for personnel marooned by sudden weather changes.
- Height: about 25 metres above the sea surface
- Width: about 15 metres
- Length: about 20 metres
- Weight: 700 tonnes – exclusive of foundation

The function of the substation is to transform (convert) the energy produced in the offshore wind farm from the 33 kV level to 132 kV, which prevents grid loss. The substation has a maximum performance of 180 MVA.

HOW NYSTED OFFSHORE WIND FARM WAS BUILT

IN JUNE 2002, A CONSTRUCTION SITE WAS ESTABLISHED AT THE PORT OF GEDSER, WHERE ABOUT 300 PEOPLE HAVE WORKED ON THE PROJECT. THE ACTUAL CONSTRUCTION WORK WAS MANAGED FROM THIS SITE.

THE PRINCESS AND THE PEA

The foundations of the offshore wind turbines were manufactured in the Polish port of Swinoujscie. From there, they were sailed to Rødsand on barges, a 24-hour journey.

Before the foundations were lowered into place, the seabed was prepared about as meticulously as in the fairy tale The Princess and the Pea. The first phase saw the excavation of up to 10 metres of seabed sand and mud, a necessary step to reach "firm ground". After that, a bed of chipping was laid and adjusted to the millimetre, so that all wind turbines are aligned absolutely vertically.

The foundations were lifted into place by the crane Eide Barge 5, which is constructed on a barge. Previously used to place the foundations at the Middelgrunden offshore wind farm, Eide Barge 5 was redesigned to establish Nysted Offshore Wind Farm. Eide Barge 5 lifts up to 1,450 tonnes.

Eide Barge 5 lifted the foundations in place with a special lifting yoke, which lifts the foundations the same way a hand lifts a glass of brandy. The foundations were placed at a tolerance of ±30 cm from the theoretical turbine position and the foundation turned at a tolerance of ± 1°. The foundation was lowered to hover just above its final position, after which height and foundation inclination were checked before the crane lowered the foundation the last few centimetres and let go.

Below the sea surface, the foundation is in principle constructed as a big, heavy sole plate with a hexagonal open box on top. Once the foundation is placed on the seabed, the box is filled with pebbles and gravel. Thus, the total weight of each element ranges between 1,600 and 1,800 tonnes - or the equivalent of about 400 big elephants.

The turbines were shipped from Nyborg. The port on eastern Funen suited the needs, because the location reduced the distance over which the extremely long turbine blades had to be transported on land. Each blade measures more than 40 metres, and each blade transport requires a special permit from the police. The transport from Nyborg to Rødsand is carried out by the vessel Ocean Ady. She can carry four turbines at a time, each consisting of four main parts: Lower tower section, upper tower section, nacelle and rotor. The total weight of a turbine is 250 tonnes. Depending on the weather, the trip from Nyborg to Rødsand lasts about 12 hours.

Upon arrival at Rødsand, Ocean Ady anchors and hooks on to the turbine foundation. First, the lower tower section is erected, on

top of that the upper tower section, and finally the nacelle. When these three parts are in position, the most critical operation follows: Fitting the rotor with its three blades exactly onto the nacelle, 70 metres above sea level.

When all four turbine parts have been assembled, there is still a long way to go. Several kilometres of wiring must be run inside the turbine, and all components are double-checked. Since it is expensive and difficult to perform service inspections on an offshore wind turbine, all critical components have been doubled so that the turbine will continue operating, even though a single part should fail.

THE SUBSTATION

A large barge sailed the substation from the Aalborg factory to the foundation. Next, the large floating crane Rambiz sailed out and took up position alongside the barge. Rambiz lifted the substation, the barge moved away, and the crane lowered the substation into place.

Simultaneously, cabling was used to connect the turbines to the substation. SEAS Transmission was in charge of building the wind farm substation, which transforms electricity from 33 kV to 132 kV. SEAS Transmission was also charged with landing the electricity from the turbines and expanding and improving the existing 132 kV land-based grid. A total of 59 km cable (48 km 33 kV cable and 11 km 132 kV cable) has been laid on the seabed to connect all 72 turbines to the power grid. To this should be added 18 km cable on land between Vantore Strand and Radsted, where the turbines are connected to the general power grid.

THE WORLD'S LARGEST AND HEAVIEST MARINE CABLE

The world's largest and heaviest marine cable was manufactured in the summer of 2002 by Pirelli in London. The cable was delivered as one long cable, reaching 11 km and weighing 800 tonnes.

The large cable took three days to load at a speed of 7 metres per minute. The cable was carried from the factory to the cable ship Atlantis via a 400-metre long conveyor belt. The part of the cable laying on the conveyor belt weighed 30 tonnes. The marine cable is the largest and heaviest cable ever produced. It has a diameter of 20 cm, and each metre weighs 72 kg.

Having loaded the cable, Atlantis sailed for Denmark.

The marine cable was brought ashore on a foggy Thursday morning, being pulled first through a pipeline in the seabed and then in a trench to the land-based cable, about 150 metres from the coast.

The conveyor belt leaves the Pirelli factory in the background to the right via a bridge high above the Thames and descends into the cable ship Atlantis, a distance of 400 metres.

Atlantis laying the marine cable at Vantore Strand.

From a turntable at the factory, the cable was carried on a 400-metre long conveyor belt to the cable ship Atlantis, anchored in the Thames.

THE TEST TURBINE AT RØDBYHAVN

In September 2002, a test turbine was erected at Rødbyhavn. The test turbine gave the operators some initial experience of erecting, commissioning and servicing turbines before being put to the real test at the offshore site.

After several days' preparation, two cranes lifted the three-bladed rotor 65 metres. A spectacular sight witnessed by both the media and around 100 locals.

Apart from the 3.5-metre high "sea foundation", the test turbine is identical to the 72 turbines at Nysted Offshore Wind Farm. The test turbine will remain at Rødby until the summer of 2005 and can be studied in detail until then. It is a breathtaking experience to stand beside the turbine, which at 107 metres seems virtually monumental.

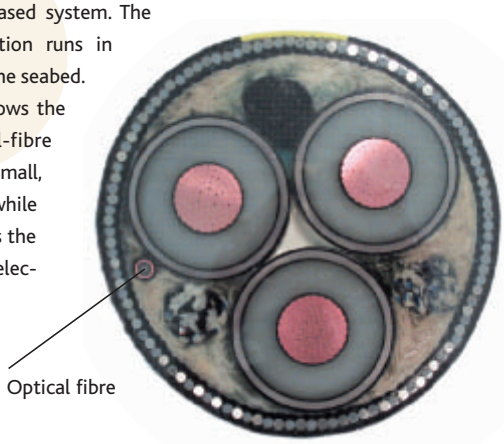
FACTS ON THE TEST TURBINE:

- Siemens Wind Power 2.3 MW offshore wind turbine
- Height to upper blade tip: 107 metres
- Height, tower: 65 metres
- Rotor diameter: 82.4 metres
- Sweep area: 5,330 m^2, corresponding to an area larger than a soccer field
- Weight: about 250 tonnes, exclusive of foundation
- Cut-in wind 3 m/s (light breeze)
- Full production from 13 m/s (strong breeze)
- Expected annual power production: 7,000 MWh, corresponding to the consumption of 1,300 households

HOW TO CONTACT AN OFFSHORE WIND TURBINE

Each offshore wind turbine is equipped with a network-based monitoring computer. It has its own network address, allowing communication with the wind turbine via the Internet. This setup gives the monitoring system several advantages over conventional monitoring systems. Service technicians can download drawings, tables, manuals, etc., when they perform service checks. E-mail allows the turbine to communicate directly with the service department and/or sub-suppliers. This makes for fast, easy on-site solutions to problems. In addition, the monitoring system can supply more - and more detailed - information, which helps to increase reliability.

As an extra safety facility, the turbine also has a conventional monitoring system, which is directly hooked up to an optical-fibre connection, and which operates independently of the network-based system. The optical-fibre connection runs in the marine cable at the seabed. The photo below shows the cable. The optical-fibre connection is the small, thin ring to the left, while the large rings carries the three phases of the electricity produced.



WHAT ABOUT THE ENVIRONMENT?

Assessments of the environment were made both before and during the erection of the offshore wind farm. ENERGI E2 will also conduct environmental surveys now that the farm has been erected. An EIA report (environmental impact assessment) has been prepared, mapping the basic state of nature and environment conditions. Satellites monitor seals at Rødsand, and other aspects of animal and plant life are regularly registered.

SEABED IMPACTS

Cable laying and excavations for foundations are expected to cause a temporary loss of 3-4 tonnes of bottom-living fauna and around 250 tonnes of blue mussels. But once the farm has been erected, wildlife population will quickly return to their original numbers. Studies even indicate that the turbine foundations offer excellent growth sites for algae and mussels. The new habitats mean that the offshore wind farm will create more life than it destroys, as the animals higher up in the food chain will benefit from the extra nourishment.

The turbine foundations are expected to function as artificial reefs, thus offering habitats for animal and plant species that previously lacked good living conditions at Rødsand. Furthermore, a blue mussel community corresponding to more than 550 tonnes is expected to develop, which would more than offset the loss sustained during the construction phase.

NOISE AND VIBRATION FROM WIND TURBINES

When in operation, the wind turbines will emit noise and vibrations to their surroundings. Assessments based on measurements performed on existing offshore wind turbines show that underwater noise will only be audible to porpoises at a distance of a few metres - and to seals perhaps up to 20 metres away from the foundations.

Noise propagation above water has been calculated as a noise contribution of about 10 dB at the neighbouring seal reserve and a few dB at the nearest coastline. By way of comparison, a person breathes at the noise level of about 20 dB – and the noise level of a typical living room stands at about 40 dB.

OFFSHORE WIND FARM MAINTENANCE

Maintaining and servicing the wind turbines will give rise to some traffic in the area, but this traffic will not differ from that of fishing vessels and yachts sailing through the area today. A great number of the service jobs will be carried out inside the turbines, and animals such as seals will be disturbed only when external servicing is needed.

SEALS, OFFSHORE WIND TURBINES AND THE ENVIRONMENT

How will seals respond to offshore wind turbines? SEAS, ENERGI E2, Dong and Sydkraft have commissioned the National Environmental Research Institute to study these aspects as part of a comprehensive environmental survey, aimed at clarifying all environmental aspects of the offshore wind farm at Rødsand.

The area surrounding Rødsand has up to 200 common seals and up to 20 of the somewhat bigger and - in Danish waters - more rare grey seal. The seals at Rødsand are part of a large group living in the Øresund, the western Baltic Sea, the Femer Belt, the southern Great Belt and the Smålandsfarvandet. But we actually did not know how far the seals range before we started the surveys.

The turbines and the increased traffic in the area might affect the seals, and we are also investigating whether changes might occur in seal fodder populations (fish). To determine whether the seals respond to these aspects, we have mapped seal behaviour:

- How far do they swim to find food?
- How much of their food do they find in the wind-turbine area?
- How much time do they spend onshore?

Seals spend much time onshore in the reserve found a few kilometres from the wind farm. Seal habits vary when it comes to finding food. Some seals loot fishing nets much to the annoyance of local fishermen. Other seals seek out deeper waters in the Femer Belt and even farther. By comparing seal behaviour before and after the establishment of the wind farm, we can determine whether the offshore wind farm has impacted on the seals in any way.

SATELLITE TELEMETRY

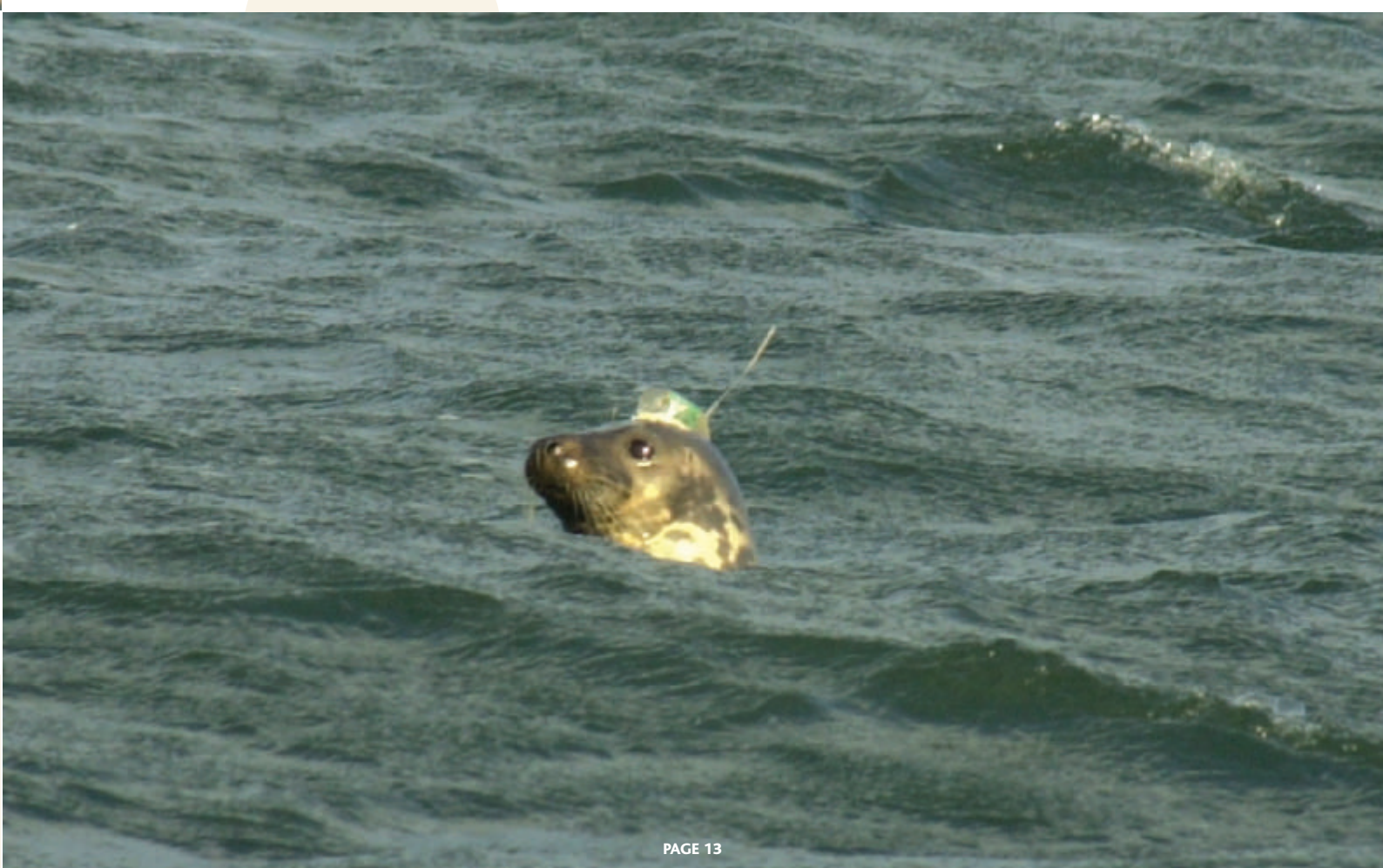
To study seal movement in the sea, where and how often they go ashore, a small number of seals in the seal reserve at Rødsand have been tagged with satellite transmitters since the autumn of 2000. The National Environmental Research Institute is in charge of tagging the seals.

To catch the seals, a wide-meshed floating net was spread between two boats. This procedure caught the seals swimming between the two boats on their way to the seal reserve.

The seals were tagged with radio transmitters. Glued onto the top of seal heads, the transmitters could transmit when the animals surfaced to get their bearings and air. The transmitter does not inconvenience the seals and falls off when they moult during the summer.

Satellites pick up the transmitter signals and decode their origin. This has enabled researchers to form a picture of how far the seals roam, where they eat, where they come ashore, etc. The distance that the seals roam varies greatly. Some stay in the local area, while many have ventured as far as the shores of Riga.

Now, when the farm is in full operation, new surveys will be made to determine whether its presence has changed seal behaviour.



ARCHAEOLOGY IN THE WAKE OF POWER

13,000 years ago, the Rødsand area was dry and habitable for humans where the turbines now stand. Archaeological finds prove that people lived at the island of Lolland at that time. However, no signs of settlements have been found in the offshore wind farm area.

FINDS IN THE GULDBORGSUND AND THE STORSTRØMMEN

In connection with the improvements that the Nysted Offshore Wind Farm necessitated for the electricity grid, marine archaeological surveys were made in the Storstrømmen and Guldborgsund, where the cable was embedded into the seabed. The Department of Marine Archaeology of the National Museum carried out the surveys. Since the last Ice Age, water levels have risen and the coastal line receded. As a result, we can find Stone Age settlements under the water. In Guldborgsund, such a settlement has been found from the Farming Stone Age.

A rare find was discovered at the settlement, an intact flint knife dating from 2000 B.C. Flint knives were status symbols in the Stone Age, just like expensive cars are today. The knife was fashioned after contemporary Bronze Age knives from the European mainland.

The arrowhead dating from 6000 B.C. is an even more extraordinary find than the flint knife. It was found in the Storstrømmen, 11 metres down, in a settlement from the Hunter Stone Age. Because the current in the Storstrømmen is very strong, it is incredible that this small arrowhead could remain in place for 8000 years until archaeologist found it. The arrowhead is sharp, unworn by the sands and water of time. Equally amazing, archaeologists were able to find this almost paper-thin arrowhead in the many cubic metres of mud removed from the seabed.

ST GEORGE'S LOST RUDDER SALVAGED

During the work on Nysted Offshore Wind Farm at Rødsand, divers made a remarkable find at the beginning of 2003. They found the rudder lost from the British ship-of-the-line HMS St. George in November 1811.

ABOUT THE RUDDER

The discovered rudder is unusually well-preserved. Protecting the ship against shipworm attacks, the copper sheathing is still intact. The rudder length, about 11.5 m, and the number of its brass fittings, seven in all, correspond exactly to the original blueprints for the ship. The broken pintles attest to the violence with which the rudder struck the seabed. Fittings and rudder pendants, which should have fixed the rudder to the ship, are still visible.

The flint knife is a beautiful, well-preserved example of a status symbol from 2000 B.C.

ST. GEORGE'S DAMAGED AT RØDSAND AND WRECKED AT THORSMINDE

Late in 1811, a small British squadron assembled about hundred merchant vessels in the bay of Hanø to escort them safely through Danish waters. After many misfortunes, the convoy departed, but sailed into a storm in Femer Belt, where it anchored. Of the 120 merchant vessels, 44 were damaged or lost. A medium-sized merchant vessel went adrift and severed the anchor hawser of St. George, cutting it adrift. In an attempt to prevent the ship from running aground, the masts were cut down, but shortly after the ship struck the seabed. The crew threw cannon and other goods overboard to raise the ship off the reef at Rødsand. Time and again, the rudder hammered into the sand reef, ultimately being torn from its pintles, although it remained hanging in the rudder pendants.

Sometime as the storm raged during this dramatic day, the ship lost its rudder. Slowly, the storm abated. The waters amassed in the Baltic Sea ran back into the Øresund and the straits, causing a momentary high tide that brought the ship afloat, allowing the crew to shift it to its original anchorage from before the storm. The next couple of days, the convoy reassembled, and an emergency rudder was made for St. George, so the voyage could continue. St. George was towed by one of the other squadron ships, ship-of-the-line Cressy. At Vinga off Gothenburg, more merchant vessels joined the convoy, and, having taken on provisions, the convoy again headed for Great Britain. But the ships ran into another gale, and on 24 December, Christmas Eve 1811, the heavy seas wrecked two ships-of-the-line, St. George and Defence, off Thorsminde on Jutland's west coast. Of the 1,425 crew members on the two ships, only 18 were rescued. Today, the rudder is exhibited at the Strandingsmuseum St. George at Thorsminde, where other artefacts from St. George are also on display.

INFORMATION AND ACTIVITY CENTRE AT NYSTED

The Information and Activity Centre at the Nysted harbour is a combined exhibition that both explains about the Nysted Offshore Wind Farm and functions as an appetizer to the experience centre "The world of winds", which the local authority of Nysted plans to build.The appetizer section tells the general story of wind energy. The Nysted exhibition is the outcome of a partnership encompassing the local authority of Nysted, the consortium behind Nysted Offshore Wind Farm, Siemens and SEAS-NVE.

The exhibition allows visitors to take a virtual helicopter ride through the offshore wind farm as well as try various other experience modules, including a miniature wind tunnel and an interactive quiz. Visitors can also study exhibition boards explaining how offshore wind turbines are made, environmental impact assessments, electricity's path from wind turbines to hair driers, etc. On the three PCs, visitors can see a visualising film, featuring the offshore wind farm, browse the Offshore Wind Farm website, and use a joystick to take a virtual helicopter ride through a 3D simulated version of the offshore wind farm.

The exhibition section on the general aspects of wind energy offers various activities for visitors to try. Visitors can generate power with a handle and answer questions on wind energy; children can cut and paste their own little wind turbine; and in a wind tunnel visitors can use their hands to experience how wind feels at different wind speeds.

Last, but not least, the exhibition offers a telescope from where visitors have been able to follow the offshore construction site, and, now that the farm is completed, can study the farm from a distance.

The exhibition is located at Nysted harbour, adjacent to the tourist office, and entry is free.

OPENING HOURS

June - September:
Mondays - Thursdays 10.00 am - 4.30 pm
Fridays 10.00 am - 12.00 noon
Saturdays 11.00 am - 3.00 pm

October - May:
Mondays - Thursdays 10.00 am - 4.00 pm
Fridays 10.00 am - 12.00 noon
Saturdays 11.00 am - 3.00 pm

INFORMATION AND EXPERIENCE CENTRE

Strandvejen 18
DK-4880 Nysted.

More information on the Nysted Offshore Wind Farm is available at:
www.nystedwindfarm.com

WHO CONSTRUCTED THE NYSTED OFFSHORE WIND FARM AT RØDSAND?

Nysted Offshore Wind Farm was built by a consortium consisting DONG Energy (80 %) and E.ON Sweden (20 %). DONG Energy operates Nysted Offshore Wind Farm.

SEAS-NVE Transmission is the owner of the grid connection, i.e. the cabling on land and at sea, and of the substation of the Offshore Wind Farm.

Suppliers

Wind turbines: Siemens Wind Power
Foundations: Per Aarsleff/Ballast Nedam
Turbine cables: ABB
Scada: ABB
Marine cables: Pirelli
Substation: Bladt Industries

ProGrafica as

NystedHavmøllepark

www.nystedwindfarm.com