

Clean power from the sea

Large wind parks at sea replace
new power stations on shore

Eskil Sørensen, Finn Nielsen

About one fifth of the electricity demand in Denmark is covered by wind power, which makes Denmark the leading wind power nation in the world. For many years, new windfarms were located on land, but today more and more of them are located at sea. Two large offshore wind parks, whose output can be compared to medium-sized power stations, now deliver almost four percent of Denmark's electricity demand or 25 percent of its wind power generation. ABB is an important supplier to these parks – providing transmission equipment, generators and low- and medium-voltage products and SCADA¹⁾ systems.

Alternative energies

Wind is in the eye of the storm over global warming and it is becoming increasingly relevant in the fight against CO₂ emissions. Denmark is a leading producer of wind turbines for electricity generation and two of the world's leading companies are based there – Siemens Wind Power (previously named Bonus Energy) and Vestas Wind A/S, the largest wind turbine producer in the world. This has created a knowledge base that other producers are eager to tap into; hence they are locating research units in Denmark. A network of sub suppliers to the wind turbine producers has emerged in the same area. This concentration of know-how and manufacturing skills is essential for the development of wind turbines into larger and larger units: Wind turbines now exist with wingspans of 60 meters and towers reaching a height of close to 120 meters. Parallel to this development is an increasing academic interest, which is reflected in the education and training of expertise at the surrounding universities and wind institutions such as Risø research center.

History of wind

ABB in Denmark is also a member of this knowledge-environment, and has over the last 25 years developed a substantial expertise in the area of power generation from wind. ABB's cables and transformers, generators and motors are but a selection of the products it delivers to the wind tur-

bine manufacturers. Hence, when the Danish-based manufacturers export large wind parks to California or Spain, an important portion of the equipment often comes from ABB. As a matter of fact, wind contributes a large part to ABB Denmark's revenue.

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Just a few years ago, 50 percent of the world's wind turbines came from Danish companies. However, today several other producers have entered the market such as General Electric from America and Suzlon from India. Wind power has become a global business with significant competition; Danish producers control 30 percent of the market. With an annual expansion of around 20 percent during the last few years, this market share is equivalent to a substantial growth in the local Danish wind industry. As a matter of fact, this sector is the Danish industry segment seeing the greatest boom, having grown from \$ 500,000 10 years ago to today's figure of \$ 4 billion (according to the Danish Wind Energy Association). This implies that the Danish wind industry is constantly in

need of new employees. Today 21,000 people are employed by the industry in Denmark and it is getting difficult to find the necessary talents.

The Danish wind adventure commenced during the oil crises of the 70s. At first, small wind turbines were built, often by the local blacksmith. By the 80s the development had become more professional and industrially-produced wind turbines marked their breakthrough with the introduction of 55 kW units. Since these early days, several new generations have been developed and today's turbines are 50 times more powerful. The market offers 2 MW and even 3 MW turbines. The biggest commercially available unit today is 3.6 MW, but larger turbines are already in the pipeline.

Wind turbines at sea

There are good reasons why the energy industry is prepared to face the difficulties of building wind parks offshore. As the wing span and the height of the wind turbine have grown, it has become more and more difficult to find acceptable locations to erect these towers, especially in densely populated countries such as Denmark. There is a limit to how many wind turbines people are willing to accept in their landscape.

Footnote

¹⁾ SCADA: Supervisory Control and Data Acquisition, a large-scale distributed monitoring and control system

1 The Nysted wind park consists of 72 wind turbines, each with a max capacity of 2.3 MW



The second reason for moving off-shore is related to the fact that the wind is somewhat stronger over the sea, which results in higher electricity production – in the best case as much as 50 percent more.

Countering these benefits is the higher cost associated with wind parks at sea such as constructing the foundation for the tower. The higher salt concentration requires corrosion resistant components. The tall towers are carefully treated with special paint. The machinery is often placed indoors where the humidity can be kept at a level of less than 50 percent. Maintenance cost is also higher since crews have to be flown back and forth with helicopters. The energy utilities are justifying these additional costs for offshore based wind farms by the increased electricity generation.

In Denmark, installed wind turbines produce an aggregated 3100 MW of power, which is equivalent to five large power plants, hence save the equivalent of four million tons of CO₂ annually.

Nysted off-shore wind farm

Based on a decision by the Danish Parliament (Folketinget), two large off-shore power parks were constructed as early as 2002 and 2003. Together these parks can meet almost four percent of Denmark's electricity demand. ABB was a supplier of essential equipment to both these installations. The Nysted sea-based wind park for power generation was commissioned in 2003. At that time it was the largest off-shore wind farm in the world ¹. The 72 wind turbines produce a maximum power of 165.6 MW; the equivalent of a medium-sized power plant. Each turbine delivers its power to the aggregating center ² by a 33 kV cable. Here the power is transformed to network voltage levels and delivered to shore by a 132 kV cable. This park can satisfy the power demand of 150,000 households.

The atmosphere is relieved of 500,000 tons of CO₂ annually, equivalent to one percent of Denmark's total CO₂ emissions. This is a significant contribution to the reduction of greenhouse gases. In Denmark, installed wind turbines produce an aggregated 3100 MW of power, which is equivalent to five large power plants, hence save the equivalent of four million tons of CO₂

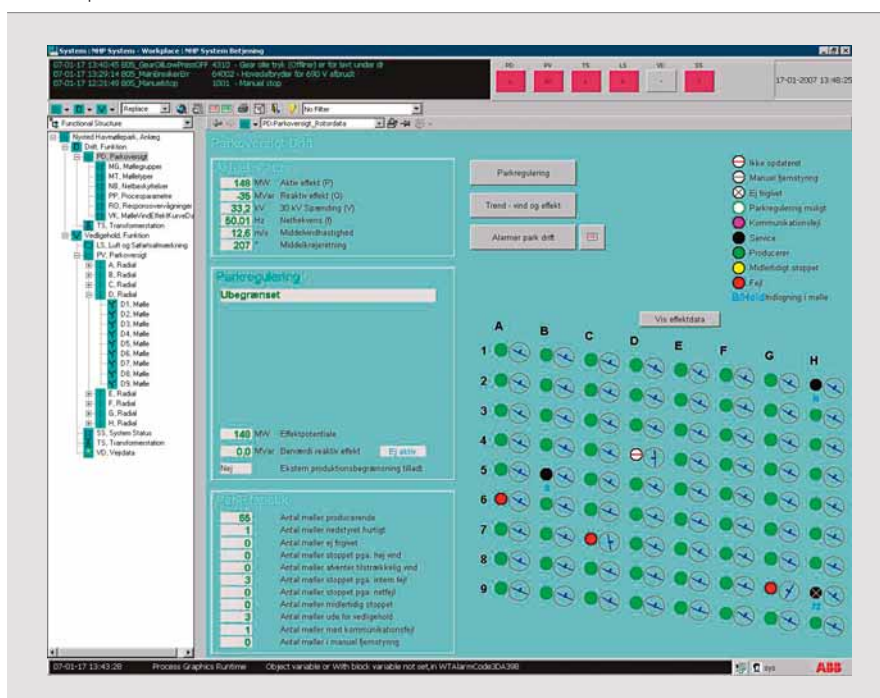
annually. The Nysted offshore wind park was designed to produce 500,000 MWh annually. This goal has been more than met.

More off-shore wind power is in preparation. The Danish government has recently announced permission to build two new wind parks off-shore. These will be commissioned in 2009

² Transformer unit for the aggregation of the 72 wind turbines of the park

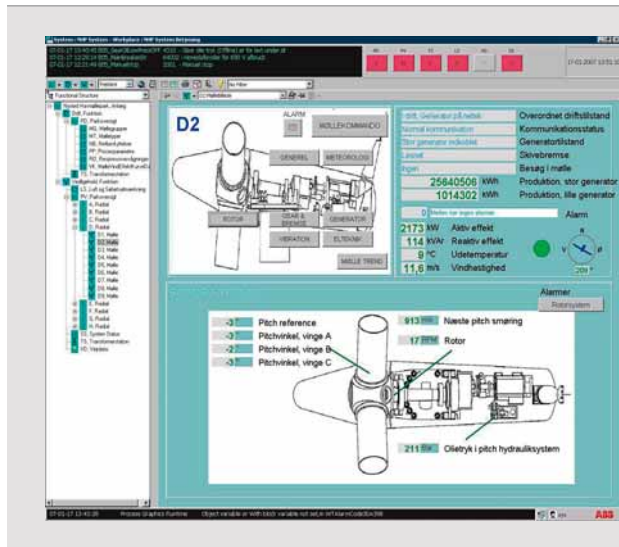


³ The operators' overview of status information for all 72 wind turbines



Alternative energies

4 "Drilling down" to the status details of an individual wind turbine



and 2010. DONG Energy A/S has been appointed to build the park located at Horns Rev and a consortium of DONG Energy A/S and E.ON Sweden AB are the winners for the construction of the park at Rødsand. ABB has already been awarded an order and several more are under way.

Off-shore wind park as power station

A network of 72 towers, such as Nysted offshore wind farm, requires a SCADA system for control and monitoring. The system supplied was based on ABB's System 800xA with built-in redundancy. The result was a very stable system with high availability. In addition, ABB delivered all 72 transformers and generators and 45 kilometres of 33 kV sea cables to

the turbines, which are located 10 to 14 km from land. Also the on-shore cable link, which transports the power to the electricity network, was delivered and commissioned by ABB.

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The SCADA system can be used to control the aggregated power generation of the wind turbines just as such a system would control a power plant. Wind turbines obviously generate electricity in relation to how the wind blows; however, the total power can be controlled. If the electrical network calls for 100 MW to be delivered by the park, the SCADA system can regulate the production to match this demand. The operator can easily enter the required production from the park and the SCADA system figures out how many wind turbines have to be taken out of operation (or added) to balance the demand and supply. The current status of the 72 turbines can be shown to the operator as depicted in 3. From this overview, the operator

can "drill down" into individual turbines for detailed status information 4. Wind power has permitted the electrical network to reduce the use of conventional power stations. As the availability of wind power increases, situations will increasingly occur where production of clean energy will have to be throttled to avoid overloading the network. As a matter of fact Denmark, with its high percent wind based generation, has already seen situations where the wind power based energy supply has exceeded the electricity demand. Other nations will of course experience similar issues as their power production shifts to variable and unpredictable sources such as wind and sun²⁾.

Factbox Nysted offshore wind farm

- 72 wind turbines, each 2.3 MW
- Combined maximum effect: 165.6 MW
- Electricity production: approx. 500,000 MWh, equivalent to the consumption of 150,000 households
- Wind turbines are produced by Bonus Energy, today Siemens Wind Power
- The towers are 69 meters high; the wings are 40 meters long
- The Wind farm was put into operation during 2003
- Owners of the wind farm are: DONG Energy A/S and E.ON Sweden AB

Eskil Sørensen

Journalist
Odense, Denmark
es@journalist.dk

Finn Nielsen

ABB Denmark A/S
Skovlunde, Denmark
finn.r.nielsen@dk.abb.com

Footnote

²⁾ See also "Harnessing the wind" on page 33 of this edition of ABB Review.