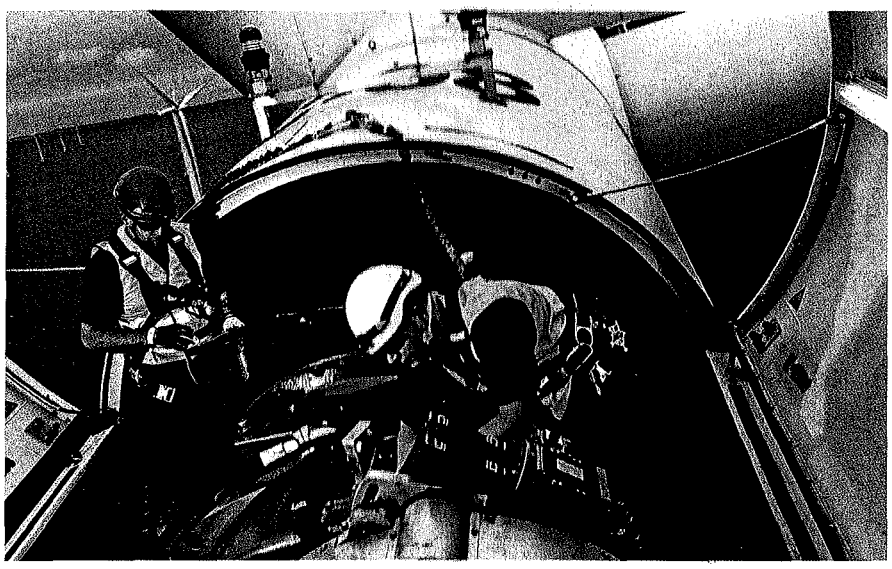
# Siemens wind turbine technology

**In 2004, Siemens acquired Bonus Energy A/S and entered the wind energy market, combining Bonus' technology expertise with Siemens global network and experience in large-scale project management. In 2002, the company opened their own blade factory in Aalborg, Denmark, a significant milestone as previously, subcontractors had manufactured most of the major components. With an accumulated market share of seven per cent, Siemens Wind Power is a world leader in the manufacture of wind turbines.**

**Henrik Stiesdal, Chief Technology Officer, Siemens Wind Power Business Unit**

Henrik Stiesdal, Chief Technology Officer at Siemens Wind Power Business Unit, attributes Bonus Energy's solid approach as to why Siemens Wind Power is such a popular choice for their clients. "Bonus Energy always adhered to relatively simple business practices," he notes.



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"Conservative design, keeping promises and reliable performances. As a consequence, Bonus was the only company to survive in the wind industry in the late 1980s when the American market collapsed. It was confirmation that our business principles were correct. People know that when they buy from us, they get quality and a good, solid design."

The prevalence in recent years for large-scale wind farm developments has been embraced by Siemens. Project management on a monumental scale is required to build these wind farms and Siemens has the experience and proven abilities to deliver. Middelgrunden Offshore and Nysted Offshore, both in Denmark, are prime examples of how Siemens have contributed to offshore wind.

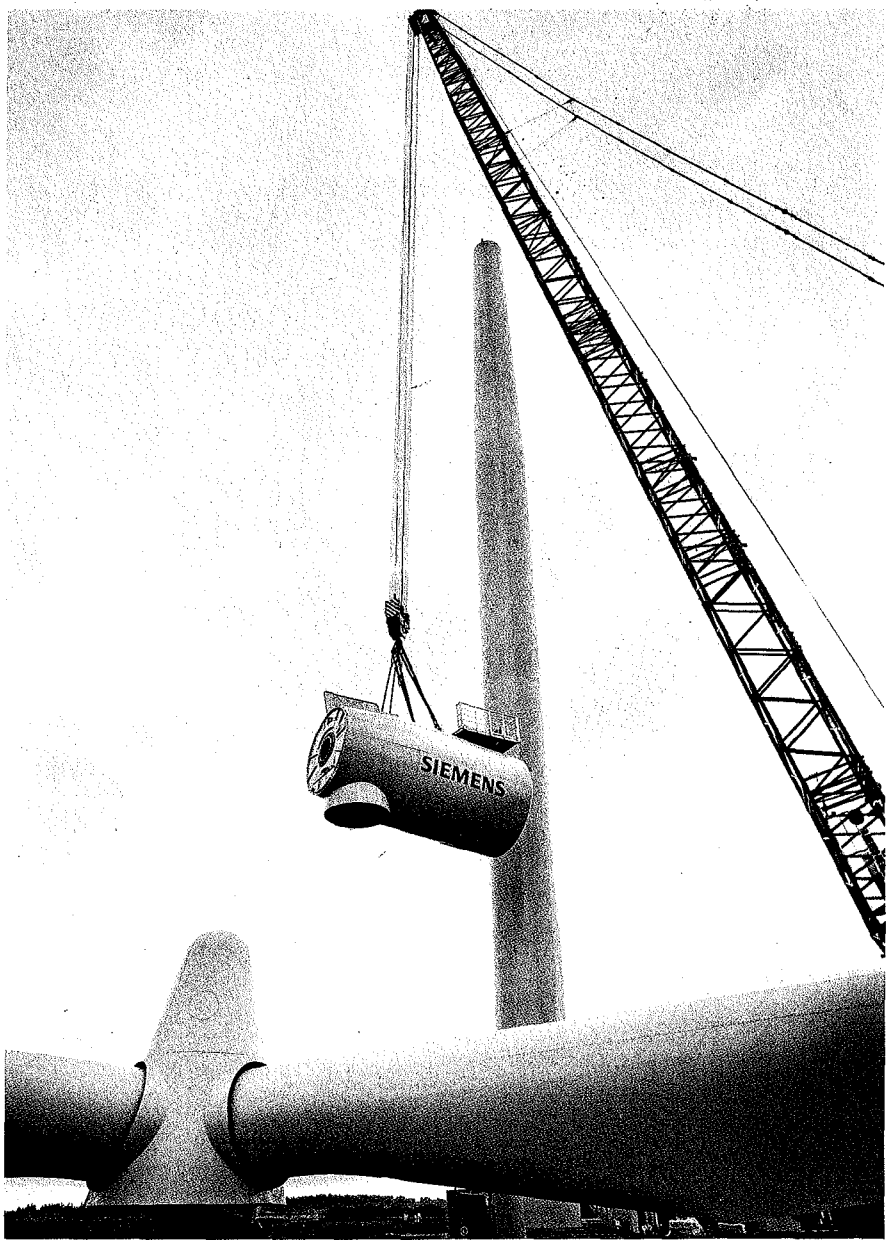
"At the moment our workhorse is our 2.3 MW machine," remarks Henrik Stiesdal. Siemens SWT-2.3-93 wind turbine is an upgrade of the standard SWT-2.3-82 turbine. It includes the new B45 blade and a rotor diameter of 93 metres, which means that there is a 25 per

cent increase of the swept area, compared to the SWT-2.3-82 turbine, to 6,800m². The three-blade rotor includes pitch regulation for power output optimisation and control. Rotor speed is variable, which maximises the aerodynamic efficiency and speed compliance minimises the dynamic loads on the transmission system, with a range between 6-16 rpm. The rotor hub is sizeable and can accommodate two service technicians comfortably while maintenance is carried out. The rotor weighs 60 tons. "We are just introducing a new 101 metre rotor for sites with low or medium wind speeds," Stiesdal confirms.

Siemens B45 blades are manufactured using Siemens' IntegralBlade® process, which involves the blades being cast in one piece and avoiding any potential weakness at glue joints. "One of the most important aspects of our technology is our blade manufacturing process, where we do things unlike anyone else," remarks Stiesdal. The blades measure 45 metres and are feathered, minimising wind loads during standstill under extreme wind conditions. The gearbox on the SWT-2.3-93 is a three-stage planetary-helical design, which provides a compact high-performance construction and allows the passage of power and control signals to the pitch systems. Equipped with large-capacity cooling and filtering systems, the gearbox ensures optimum operating conditions.

The fail-safe disc hydraulic mechanical brake fitted to the gearbox high-speed shaft represents the secondary safety system of the turbine. The SWT-3.6-107 turbine is mounted on a tapered tubular steel tower, which is fitted with a personnel hoist and has a hub height of 80 metres or site specific.

The wind turbine operates automatically, self-starting when the wind reaches an average speed of approximately three to five metres per second. During operation below rated power, the pitch angle and rotor speed are continuously adjusted to maximise the aerodynamic efficiency. Rated power is reached at a wind speed of approximately 13 – 14 m/s. At higher wind speeds, the output is regulated at rated power. The dynamic loads on the transmission system are minimised by speed compliance during



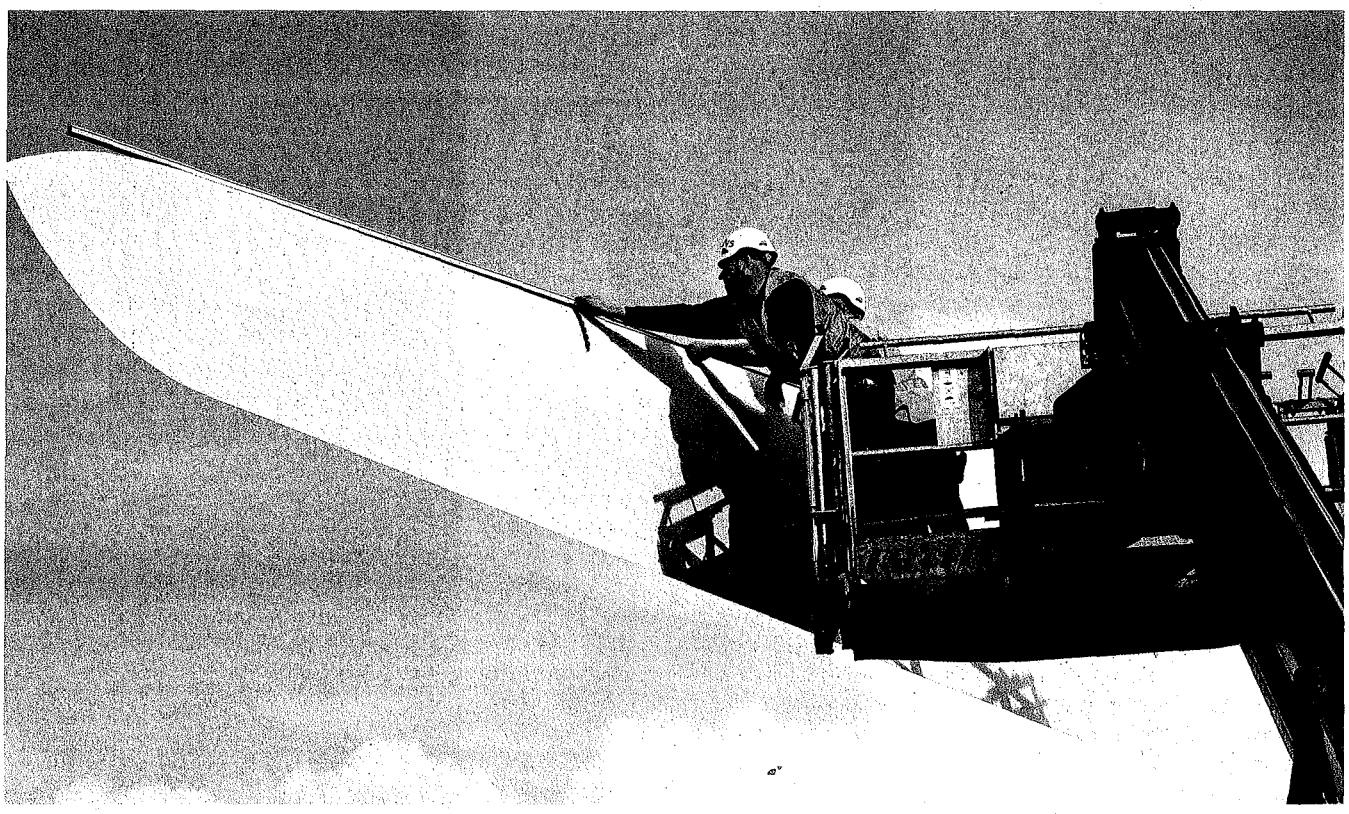

**In today's current financial crisis, it is difficult to predict where onshore and offshore wind power will be in the future**

power regulation. When the average wind speed goes above the maximum operational limit of 25 m/s, the turbine is shut down by feathering of the blades and is reset automatically when the wind drops below the restart speed.

The SWT-3.6-107 turbine is equipped with the unique WebWPS SCADA system, which offers remote control and a variety of status views and useful reports from a standard Internet Web browser. The status views present electrical and mechanical data, operation and fault status, meteorological data and grid station data.

In addition to the WebWPS SCADA system, the turbine is equipped with a Web-based Turbine Condition Monitoring (TCM) system. The TCM system carries out precise condition diagnostics on main turbine components continuously and in real time. Continuous comparison of current vibration spectra with established reference spectra enable the system to give an early warning of potential component failures.

The SWT-3.6-107 turbine complies with all currently valid grid code requirements on relevant markets. Voltage and frequency control and other grid-related adjustments can be implemented by the integrated Park Pilot facility in the WebWPS SCADA system, and the turbine has ridethrough capability for all normal faults.



**Rotor speed is variable, which maximises the aerodynamic efficiency**

"We have a 3.6 MW machine which is our largest machine and is used for offshore wind farms," Stiesdal says.

Lillgrund, the 110 MW offshore wind farm off the west coast of Sweden, was developed using 40 Siemens SWT-2.3-93 wind turbines and has been operating since December 2007.

### Lightning protection

All Siemens wind turbines from 1.3 MW and higher are fitted with lightning protection. The turbines are therefore protected against direct and near strikes and the Siemens protection system has shown good performances in wind turbines across the globe. Wind turbine blades are protected with lightning receptors fitted close to the tip and projected slightly above the blade surface on both sides. For blades that are longer than 40 metres, lightning receptors are fitted at locations along the blade.

Electrical equipment within the hub is completely protected by the Faraday cage of the hub. The hub casting acts as a natural bonding conductor to the main shaft. The nacelle and tower are also protected by natural bonding. Surge arrestors in the main supply and communication connections by fibre optical cables provide protection from the effects of nearby strikes. The power supply of the control system is based on a UPS that provides a clean electrical environment for all computers and electronics.

### Progression from 1991

In 1991, Siemens provided turbines for the world's first offshore wind farm in Denmark. Since then, the turbine has not progressed all that much. However, Stiesdal is quick to point out that this is not a bad thing; "It just means we were actually quite successful in making adaptations for offshore conditions. The first offshore wind farm turbines had all the salient features that they have today." The key to offshore turbines is to make sure that the inside climate of the turbine remains dry. "That's the whole trick," admits Stiesdal. "Making the turbine airtight and using dehumidifiers to keep the inside dry."

"The main thing that has changed since 1991 is that the turbine nowadays has to be like a power plant," Stiesdal says. "Before, they were just machines, but now they are small power plants that can be controlled and can support the grid. Until 2002, the rule of the wind power game was that we were small players. If anything happened on the grid, our first obligation was to get off and then sort out the problem. In 2002, we were told that this doesn't work and no matter what happens, we have to stay on the grid. As a result of this, we have developed turbines that are very grid-compatible so that no matter what happens, we can stay online."

In today's current financial crisis, it is difficult to predict where onshore and offshore wind power will be in the future. "Climate awareness, and the awareness that oil will someday run out, the awareness that we use more energy than we currently have to sustain us – this awareness is growing all the time. In general, I think the future for renewable energy is extremely positive. We work with the most interesting, rewarding and meaningful technology in the whole world," muses Stiesdal. "Being in the offshore wind business has turned out to be more demanding for several players than they expected. At the moment, there are players that will become more involved, but we are the only player that has been there from the start and throughout it all."