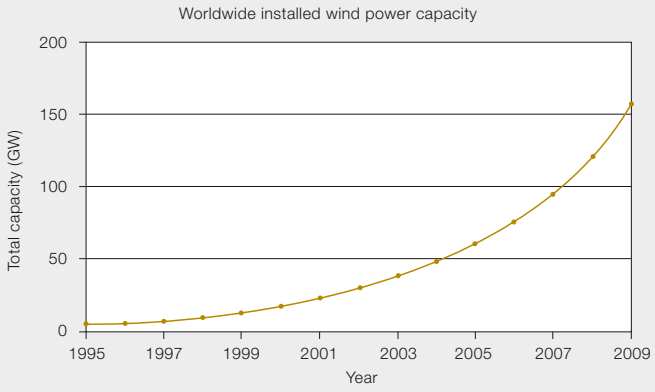
# Facing the wind

## ABB and the Alpha Ventus wind park

MELANIE NYFELER, ANDREAS MOGLESTUE – The sea has always presented a unique challenge to mankind. Humans have often been driven to the limits of their ingenuity and stamina to overcome its forces – or at least live with them. It may be that today there are no longer any unexplored shores, and that voyages that were once adventurous undertakings have become regular trading routes. The sea, however, remains a source of unpredictability and continues to test those who face its fury. One place where this manifests itself is in the erection of offshore wind turbines. ABB was involved in the pioneering Alpha Ventus project, which was built off Germany's North Sea coast. The company's contribution includes generators, frequency converters and gas-insulated switchgear. Installation and commissioning involved facing unpredictable weather, strong winds and rough seas.

**1 Worldwide installed wind-power capacity**




Source: Bundesverband WindEnergie e.V., Global Wind Energy Council

The wind is a rapidly growing source of energy. Worldwide generating capacity has increased from 4.8 GW in 1995 to 158 GW in 2009 ➔ 1, and this growth is set to continue. Wind energy has clearly advanced from the domain of experimental and niche applications to making a real contribution to the energy balance of the countries and regions that have invested in it. Although economies of scale and the accumulation of know-how have reduced the price (per MW) as well as the risk of new installations, cost efficiency is still an important objective. There is thus a trend towards larger and more powerful turbines. Interest in offshore wind farms is increasing, due both to questions over the acceptability of such huge towers in inhabited regions, and to the simple fact that there is more raw wind energy available more of the time at sea.

As simple as the logic of building offshore wind farms may seem, their realization is connected with numerous challenges. These range from the difficulties in installing and anchoring the turbines in rough seas, to assuring they function as intended over long periods of time despite being battered by strong winds, high waves and a moist atmosphere, and being difficult to access for repairs and maintenance.

The Alpha Ventus wind farm is an experimental installation located 45 km north of the German North Sea island of Borkum ➔ 2. It is a joint project of the utility companies, E.ON Climate & Renewables, EWE and Vattenfall Europe. The installation is of experimental nature, and experience gathered here will flow into other offshore projects. The Alpha Ventus windpark features 12 turbines each rated at 5 MW. In a first phase, six turbines supplied by Multibrid were installed in a grid-like arrangement on an area of 4 $km^2$ – standing about 800 m apart. In a second phase, the wind farm was extended by the addition of six RePower turbines. The Alpha Ventus turbines are the largest wind generators installed in any offshore application in the world so far. The hub of each rotor is 90 m above the sea's surface, which is itself about 30 m above its bed ➔ 4. At its apex, the rotor reaches a height of 148 m, or 1 m more than the Cheops pyramid. The steel of each tower weighs about 1,000 tons, or as much as 200 adult elephants. The tips of the blades circumscribe a vertical area of one hectare, or the area of London's Trafalgar Square. In doing so, they can reach speeds of 324 km/h, comparable to a Formula 1 racing car.

> The work at sea required thorough planning. There was no way to quickly return to the support ship for a forgotten tool.

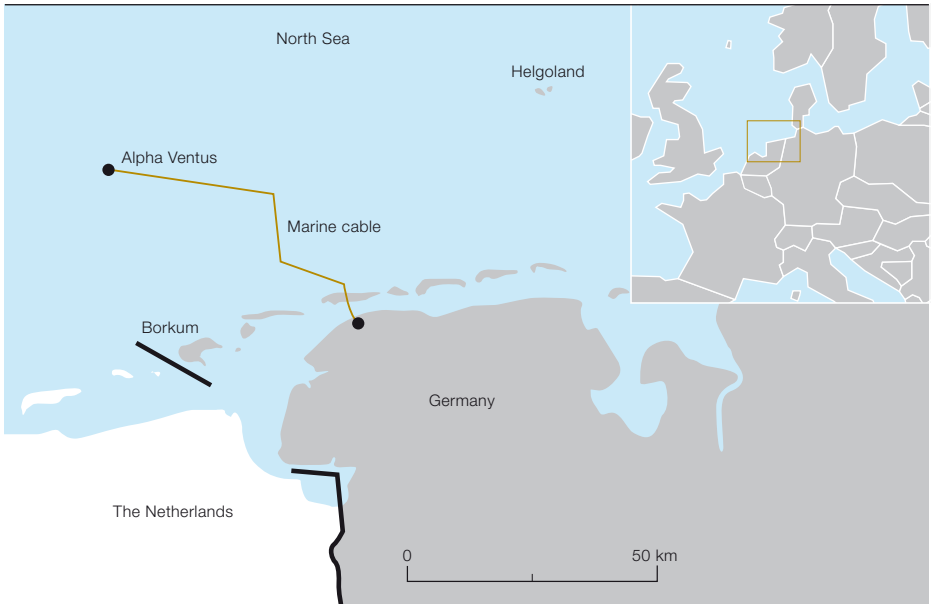
The generators for these turbines were supplied by ABB. They are permanent-magnet synchronous machines [1], a concept that enables high reliability, a crucial factor on account of their inaccessible location. ABB also supplied the PCS 6000 Wind frequency converters that connect the generators to the grid ➔ 5. These converters are sufficiently compact to fit on a single level inside each of the towers ➔ 6. A separate dedicated platform accommodates the wind farm's transformer, switchgear, control equipment and various auxiliary equipment.

The turbines of the first phase commenced operation in August 2009. This followed a commissioning phase lasting from mid July to late August. The components of the towers, including the rotors were positioned by floating crane platforms – a job requiring millimeter accuracy. In order to reduce the risk of poor weather hampering installation work, as many components as possible were pre-assembled on shore, including much of the electrical installation. Nevertheless, inclement weather forced the work to be interrupted several times. ABB was Multibrid's only sub-supplier to be on-site during the commissioning, reflecting the importance of ABB's contribution for the project as a whole. In fact up to four ABB people were on-site from mid July to late August.

**Footnote**

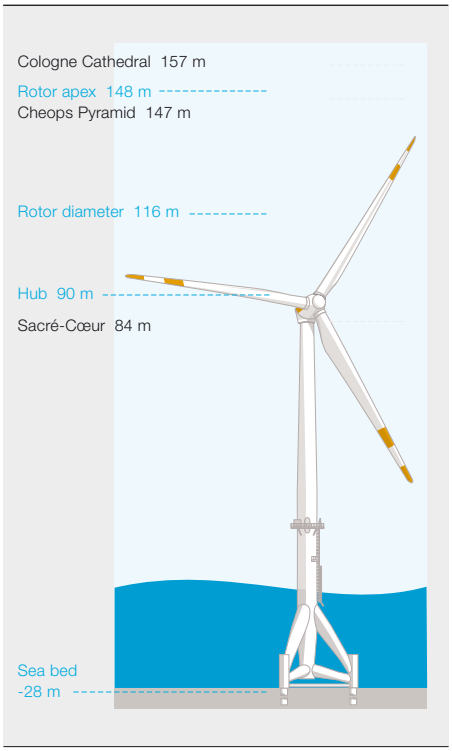
1 See also "The attraction of simplicity: Permanent magnet machines are here to stay" on pages 29–34 of *ABB Review* 2/2009.

2 The Alpha Ventus windfarm is located 45 km north of the island of Borkum




3 The commissioning of the turbines involved facing many challenges.

4 The wind turbines stand almost as tall as the Cheops Pyramid




The ABB technician, Uwe Heydel, who brought in a wealth of experience from his oil rig days, was part of the team that commissioned the frequency converters. He recalls that on account of the high waves, the docking of the inflatable boat sometimes proved a greater challenge than actually working on the electrical installations inside the tower. An additional challenge arose when during assembly, a protective bag failed to detach from one of the turbines' wings. A Multibrid employee had to rope down from the turbine's hub → 3. The man who attached this rope to the hub was ABB's Uwe Heydel. Recalling the incident later, he confesses that he would have loved to do the job himself. Such situations were part of his rigorous training, which also including simulating a helicopter crash and surviving as a castaway at sea. Uwe Heydel muses that despite being on site to install advanced technology, some of the greater challenges lay in dealing with some very low-tech problems.

The work at sea required thorough planning. There was no way to quickly return to the support ship for a forgotten tool. Communication was also a challenge. Although the support ship was equipped with a satellite phone, it was mostly at night that this crackling and unreliable link could be used for support calls.

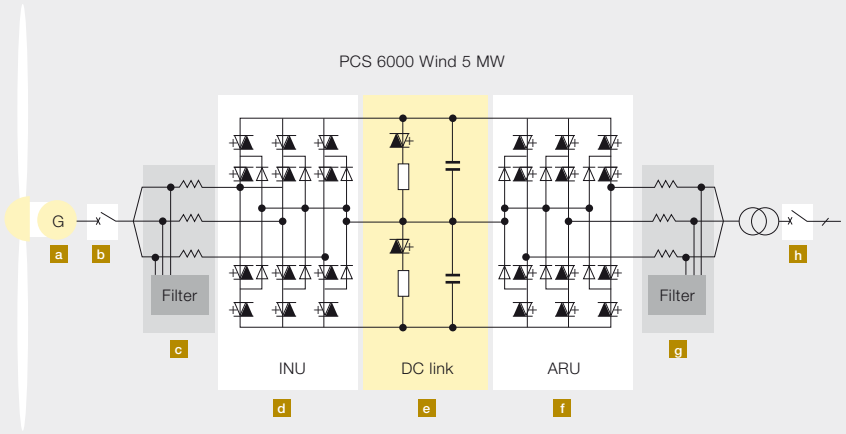
5 Offshore converter: the PCS 6000 Wind

The generators ABB supplied for the Alpha Ventus project are speed-variable permanent-magnet synchronous machines, a choice of technology selected for its low maintenance requirements in line with the inaccessibility of the location. The generator output is thus of variable frequency. ABB has developed the PCS 6000 Wind converter specifically for such wind power applications with a power above 3 MW. This four-quadrant converter is based on IGCT technology. Besides assuring the connection between the generators and the grid, the converters can absorb or supply reactive power to support weak grids. In fact they can operate in 100 percent reactive power mode to help a re-start after a blackout. Being four-quadrant converters, they can support energy flow in both directions. In normal operation, energy only needs to flow from the generator to the grid, but for blade positioning, for example, an inverse flow is required. The converter is controlled by ABB AC 800PEC controllers *).

The converter's special features include its high power density, low maintenance requirements, electromagnet disturbances and water condensation (it fulfills IP54 in terms of ingress protection). Thanks to its compact design, the converter and all its auxiliary equipment need only a single platform inside the turbine's tower.

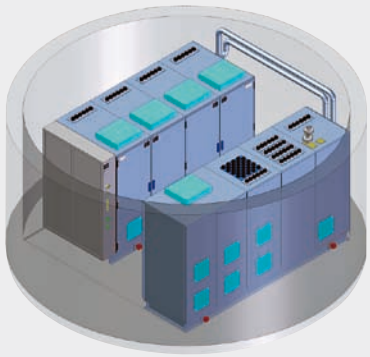
The PCS 6000 high reliability is supported by its remote service capabilities. ABB's Diagnostic Information Analysis System (DIAS) helps remotely diagnose the converter and also permits remote supervision to support local service teams.

* See also "Design patterns: Co-design patterns for advanced control with AC 800PEC" on pages 62-65 of *ABB Review* 2/2006




a Permanent magnet synchronous generator
b Circuit breaker generator
c dV/dt filter
d 5 MW generator converter
e DC link brake chopper
f 5 MW grid converter
g Grid filter
h Circuit breaker transformer

6 The entire frequency converter fits on one level inside the tower.



The tips of the blades circumscribe a vertical area of one hectare, or the area of London's Trafalgar Square. In doing so, they can reach speeds of 324 km/h, comparable to a Formula 1 racing car.

ABB's involvement did not end with assembly, but a important part of the contribution of ABB's staff lay in taking the turbines into operation and fine tuning to assure their optimal performance.

Since starting to feed power to the grid at the end of August 2009, the equipment has been performing satisfactorily. Remote access and diagnosis tools are supporting the operation. So far, ABB's technicians have not had to return to the site. The company's generators and frequency converters are weathering the challenges of this tough operating climate.

**Melanie Nyfeler**
ABB Schweiz, Communications
Baden, Switzerland
melanie.nyfeler@ch.abb.com

**Andreas Moglestue**
ABB Review
Zurich, Switzerland
andreas.moglestue@ch.abb.com

**Further reading**

– Eichler, M., Offshore but online: PCS6000 Wind converter for 5MW offshore wind turbines, *ABB Review* 3/2008.
– Sörensen, E., Nielsen, F., Clean power from the sea: Large wind parks at sea replace new power stations on shore, *ABB Review* 2/2007.
– Kreusel, J., Harnessing the wind: How the wind is leading to a paradigm change in electrical power supply, *ABB Review* 2/2007.