GERMANY

Bard turbine know-how boosts project potential

29 July 2011 by Eize de Vries , Be the first to comment

GERMANY: Europe's most integrated offshore wind-energy project Bard Offshore I is now partly in the water in the southern North Sea. Eize de Vries has a close look at where it all came together -- Bard's manufacturing base in the German port of Emden.

Bard-designed tripiles secure the turbine support structure to the seabed

Bard is no ordinary project developer. It is also a wind turbine, rotor blade and support-structure manufacturer. Its Bard Offshore I installation is a 400MW deep-water wind farm, located around 100 kilometres north-west of the island of Borkum, the most-western of the East Frisian Islands in the southern North Sea. Installation work on the project began in March 2010. Operational challenges during construction included a water depth of 39-41 metres and average wind speeds in excess of 10 metres per second.

In total, 80 Bard 5.0 wind turbines will be installed at Bard Offshore I. They are dedicated 5MW offshore turbines, the fruit of the company's collaboration with German engineering firm Aerodyn. Because Bard wanted to substantially shorten time to market, the product's key development focus was to apply proven technology and, wherever possible, incorporate off-the-shelf and semi-standard main components. The turbine design was completed within a record nine-month period.

Featuring a 122-metre rotor diameter, the Bard 5.0's box-type nacelle is 14 metres long, 8.5 metres wide and 8 metres high. The main structural part is a 76-tonne cast main chassis. The single rotor bearing, with a 3.2-metre diameter and about 0.75 metres depth, is fitted to the vertical main chassis to support the rotor.

Andreas Kolling, a spokesman for Bard, extols the virtues of German supplier SHW Casting Technologies. "To this day, only very few foundries in the world are capable of series-manufacturing components of this size, complexity and the required quality," he says.

Everything about this turbine is big. The main chassis is almost 6 metres high and 5.4 metres wide, making it one of the largest and heaviest components used in any wind turbine. Each 40-tonne hub is 4 metres long and 3.5 metres wide.

Bard 5.0's conventional fast-speed geared drive systems are supplied by Winergy and comprise a three-stage gearbox, a six-pole doubly-fed induction generator and a (partial) power-electronic converter. An unusual technological feature is the short, hollow gearbox input shaft, which is directly attached to the bearing inner ring via a matching hollow shaft that is shrunk in. The result is a short, compact drive system.

The liquid-cooled generator is mounted on a welded generator chassis, which is bolted to the main casting. The cooling system is integrated into the bottom of the nacelle's rear section.

The combination of a spacious nacelle and a compact drive system offers easy service access to all the main components. It provides enough room to manoeuvre for even major onboard repairs. The spinner can be safely accessed from inside the nacelle for inspections, service and repair of key components such as rotor-blade pitching and battery back-up systems.

The almost 60-metre-long rotor blades, which are manufactured in-house, were developed in cooperation with Aerodyn and are aerodynamically optimised. The blade

foot's diameter measures 4 metres, whereas the 28.5-tonne rotor-blade mass represents a record weight for its size.

The blades are unusual in that they comprise several cross-sectional parts, bonded together into a single assembly. This design approach differs from common blade-design solutions that typically comprise an upper and lower shell with an internal reinforcement structure. Bard claims that its blade design eliminates the need for traditional bonding seams at both the erosion-prone, rounded leading edge and the rather thin trailing edge. However, the long-term endurance and performance of Bard's turbines in the harsh North Sea marine environment remain to be proven.

Bard produces nacelles, hubs and rotor blades in its Emden facilities with direct access to deep waters. Finished components and assemblies are put directly on jack-up barges or self-propelled vessels with the aid of special-purpose multi-wheel vehicles designed for moving extremely large and heavy loads. The deep-water port access also eliminates the sizeor weight-related logistical issues associated with road transport.

Reaching for 7MW and beyond

When the Bard 5.0 was introduced in 2007, Arngolt Bekker, the company's founder, said his final aim was a much larger, 7MW-plus turbine. A first step towards this goal was achieved in February, when Bard installed two 6.5MW prototype nacelles at its existing 5MW onshore locations near Emden.

This involved removing the 5MW nacelles after three years of operation and putting new 6.5MW nacelles on top of the towers. The Bard 5.0 gearboxes and rotor bearings are key components and will be returned to their manufacturers for inspection and remeasuring. This is now becoming common wind-industry practice.

One of Bard's main demands was that the 6.5MW gearbox should be made to fit into the existing cast main chassis, while rotor diameter, rotor bearing and additional nacelle structures should be unchanged. An overall objective was to use the substantial built-in design reserves of the 5MW concept while minimising upscaling time and costs. A major challenge was that the original 5MW gearbox has an irregular cylindrical form, whereas the 6.5MW Multi Duored unit is shaped like a square-sided box.

Gearbox integration was achieved by extending the input shaft, which moves the gearbox slightly back, providing the required space within the main chassis. A second measure was to apply longer output shafts between the gearbox and the two generators. These had to be fitted on to the same generator chassis.

Matthias Deicke, drive-system expert and head of electrical systems at Winergy, explains the key differences between the gearbox concepts. "Conventional fast-speed three-stage

wind-turbine gearboxes typically comprise two planetary gear stages and a parallel-gear stage," he says. According to Deicke, the Multi Duored gearbox is designed to provide multi-load sharing.

"In the first step, low-speed input power is redistributed via a central gearwheel to eight smaller, much faster, rotating identical gear sets. The power is then stepped up further and redistributed to four gear sets as a second step and, finally, into two high-speed output shafts," he adds.

One of the main achievements of the Multi Duored gearbox was that its mass could be kept almost unchanged while increasing the power rating by one third. Another design issue that mattered to Bard was easy serviceability, including onboard component exchange without the need to remove the entire gearbox.

Multi Duored gearboxes, according to Deicke, can also be rotated 360 degrees in either a clockwise or anti-clockwise direction. "This further simplifies onboard components exchange, but could not be implemented in the Bard 6.5 due to insufficient free clearance inside the main chassis," he says, adding that the Multi Duored allows the turbine to operate with only one generator during a failure in the other unit, despite the asymmetric loads this introduces in the gearbox.

The Multi Duored Bard 6.5 is fitted with two medium-voltage synchronous permanent-magnet generators and a so-called full converter, but alternative configurations are possible. The power-electronic converter, switchgear and medium-voltage transformer are all located in the tower foot, arranged in a three-storey e-module. Electric power at 33kV is fed to the offshore high-voltage station in strings, each consisting of multiple turbines.

A second alternative 6.5MW drive solution comprises a Voith WinDrive, which makes it possible to operate the rotor with variable speed in combination with a fixed-speed generator directly connected to the grid. This eliminates the need for a power-electronic converter. Kolling says Bard would like to test both solutions in parallel but has no suitable onshore test site yet.

Putting the technology to work

Bard Offshore I construction started in March 2010 after more than a year of delays. Technical issues with the Bard Wind Lift I turbine jack-up installation vessel caused an inital hold up. Further delay was due to difficulties with the 150kV high-voltage direct-current cable that transports power from the offshore high-voltage station to the connection point with the German 150kV high-voltage alternating-current onshore transport network.

Another unforeseen hurdle that hampered installation was the occurrence of fog in windless conditions. Last autumn saw severe conditions with heavy winds and high waves. "These adverse weather conditions are particularly challenging for offshore logistics and caused all installation activities to be discontinued," adds Kolling.

Bard's Wind Lift I, a self-propelled vessel fitted with a 500-tonne crane, has been purpose built for deployment at North Sea wind-farm sites with maximum water depths up to 45 metres.

To partially make up for the past delays, a second self-propelled jack-up vessel named Thor and a third-party jack-up barge called JB 115 are now also deployed for the construction of Bard Offshore I.

By mid-June this year, Wind Lift I had installed a total of 26 foundations and 18 wind turbines, 15 of which were connected to the grid and were supplying power to the onshore network. The Thor picks up nacelles, towers and fully assembled star rotors from the Dutch port of Eemshaven, strategically located for the transfer and supply of goods for German offshore wind farms. The Thor and JB 115 both install the two tower segments, nacelles and rotors.

Bard's Kolling is positive about the generating potential of the Bard 5.0 and Bard 6.5 at the high-wind-speed North Sea sites where his company has its main focus. "The Bard Offshore I site enjoys average wind speeds of 10.5m/s. Initially, we calculated that with 4,000 annual full-load hours per turbine we would generate 20GWh per year, but current data suggests a performance that is 5% higher, at around 4,200 hours," he says. For the Bard 6.5, he expects 13% maximum additional yield compared with the Bard 5.0 under similar wind conditions.

The current project schedule aims at completing the wind farm before the end of 2012. A second 400MW German wind farm, the Veja Mate, and two Dutch offshore projects totalling 600MW have already been permitted, although not all of the necessary finance has been secured. In total, five major additional German offshore wind projects are at different permit stages.

SECURING THE SUPPORT STRUCTURE - TRIPILES ARE DRIVEN INTO THE SEABED

Bard's third prototype was installed in shallow waters at Hooksiel, near the German port of Wilhelmshaven, on a Tripile support structure designed by Bard.

A Tripile consists of three monopiles, each with a 3.9-metre outer diameter and with varying lengths, depending on water depth and soil conditions. For Bard Offshore I, the

pile length is 90 metres, while the thickness of the pile wall can vary depending on the water depth and local soil conditions.

The piles are rammed into the seabed individually with the aid of a precision-guiding frame, fitted with Wind Lift I to ensure exact positioning and spacing.

Maintenance friendly

The fourth Tripile element is a transition piece fitted with a central upright to accommodate the e-module and tower, while three downward-facing legs slide into the three piles.

A grout connection joins the piles and transition piece, which is located well above the surface for ease of inspection and operations and maintenance activities.

The Tripile features a winch system for pulling in the ingoing and outgoing electricity transport cables, eliminating the need for divers. This will save time and money, according to Bard spokesman Andreas Kolling.

Bard's subsidiary, Cuxhaven Steel Construction, manufactures the transition piece. The original component mass was 495 tonnes, but a redesign project has reduced steel use by about 10%, which simplifies the manufacturing process. Kolling says the first redesigned units are now ready and awaiting installation.