



< BACK

IN DEPTH



First new generation of offshore wind turbine

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CLEAN POWER RENEWABLES WIND

Reliability is one of the most important parameters in the design of offshore wind turbines. But the extreme environmental conditions pose significant challenges.



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The first electricity generating wind turbines were invented at the end of the 19th century. They have come a long way since then, in part thanks to the pioneering work of Barcelona-based Ecotécnia, acquired by Alstom in 2007. With solid references in onshore wind turbines, the company has launched into offshore. Its new vanguard product, the Haliade™ 150-6MW with its 150 metre rotor diameter, the world's biggest offshore wind turbine, is at the cutting edge of wind turbine technology.

“One of our key challenges was to protect the installation against the elements so that it can operate reliably for 20 years or more,” says Daniel Castell, Offshore Wind Platform Director. That required protecting all external surfaces from corrosion due to humidity and salinity. “Many external parts are made of glass fibre to withstand the elements, but all outside-facing components are coated just like a ship,” adds Castell. “Also, the inside workings are completely sealed and a filtered and dehumidified air flow is injected inside, creating a slight overpressure that avoids corrosion in the sensitive internal components.”

Other contributions to reliability enhancement have been facilitated by the failure-mode analysis that has enabled the engineers to calculate the potential failures and the time between failures. Failure-mode identification is then used as the tool to implement risk mitigation actions

in order to fulfil the demanding reliability targets. In addition, the Haliade™ 150-6MW features remote operation and remote diagnosis, with condition-based maintenance, which means that inspection is carried out without the need to be on site. If necessary, any resetting is also done from the shore, saving cost and time and allowing corrective action to be taken more rapidly.



1 __ Designed from scratch



However, the reliability of the Haliade™ 150-6MW turbine is largely the outcome of a whole series of innovations. “Instead of adapting onshore technology to offshore requirements, the Haliade™ was completely designed from scratch,” Castell stresses. A prime example is the direct-drive permanent magnet generator. Here, to improve the performance of the large structure, the magnets have been located in the rotor and the windings in the stator only. This makes the generator simpler, lighter, more robust and more reliable, compared to traditional solutions with windings in both the stator and the rotor. “This solution is new to offshore wind turbines,” adds Castell.

The direct drive approach is also an innovative wind turbine solution. In conventional wind turbine designs, the generator

speed is high and a gearbox is used to step up the shaft speed. “But a gearbox has lots of components such as bearings and gears that make the installation heavier, less reliable and more expensive to service,” Castell points out. In contrast, with direct drive the generator is directly attached to the turbine rotor. This means that the generator’s rotational speed is the same as the blade’s rotational speed. It also means that the generator itself is much larger, but it is robust enough to withstand the forces exerted on it and still make the overall installation lighter.

« It captures more wind and produces more energy per turn with a lighter solution. »

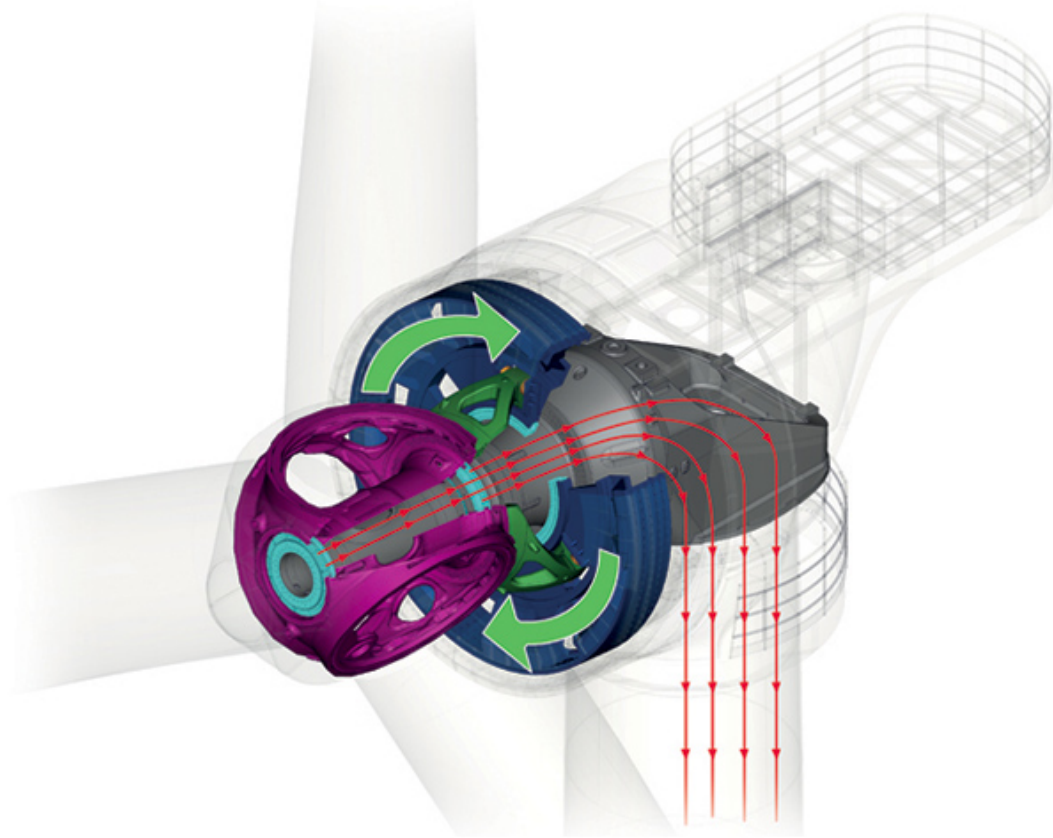
A key feature of the direct drive permanent magnet generator is its failure tolerance, thanks to having 3 independent generation lines; failure in one line does not affect the others, and operation can continue at de-rated output.

Thanks to the larger rotor diameter, it is estimated that the Haliade™ 150-6MW will show an annual energy production rate 15 % higher than the current generation of large turbines. The blades themselves are unique. At 73.5 metres in length, these blades are the largest ever manufactured for a wind turbine (the previous record was 12 metres less) and are almost as long as the total wingspan of an Airbus A380. In fact, the full diameter, at 150 metres, is longer even than a standard football field. As a result, it captures more wind and produces more energy per turn with a lighter solution, optimising the yield-mass ratio (MWh per tonne of head mass). “However, with such huge dimensions, we decided to locate assembly operations close to the shore – as close as possible to the final location – to minimise transport issues.”

**Robust, reliable and high-performance – PURE
TORQUE®**

The robustness and performance of the Haliade™ 150-6MW offshore wind turbine is due to a great extent to the innovative electromechanical layout that combines Alstom's rotor support technology with a direct drive permanent magnet generator, resulting in the superior reliability of the turbine's single-flange drive train structure that produces and transmits the electricity. The fluctuating forces and changing directions of the wind in offshore installations could be detrimental to the drive train.

The ALSTOM PURE TORQUE® feature protects the generator and improves its performance by diverting unwanted stresses from the wind safely to the turbine's tower through the main frame. This design, which is already available in Alstom's onshore turbines, separates the turbine rotor and generator. Two solid bearings transmit the main bending loads to the tower, while a flexible coupling ensures that the generator rotor receives only the turning force, the torque. This allows the minimum sufficient air gap to be maintained between the generator rotor and stator at all times, producing maximum electrical efficiency.



The ALSTOM

PURE TORQUE® feature

2 __ Commercial potential



The first Haliade™150-6MW turbine has been installed – onshore – at Le Carnet near the Saint-Nazaire manufacturing location in the west of France. It has successfully completed assembly testing and is currently in commissioning. A second turbine will be installed offshore in a wind farm off the Belgian coast by the end of 2012 to undergo further tests under real-life conditions.

Alstom recently won a major contract from the French government to supply its Haliade™ wind turbines for three offshore wind farms, one off Saint-Nazaire and two off

the Normandy coast in the north of France. Production of pre-series will start in 2013, and the commercial production in 2014. Operation is programmed to start up in 2016.

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Daniel Castell

Offshore Wind Platform Director



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