Innovation drives down offshore wind costs

O&M The cost of offshore wind power continues to fall, putting pressure on the industry to accelerate innovation for optimising operations and maintenance (O&M), the single largest cost centre of a wind turbine, writes freelance journalist Saul Trewern

ORE Catapult and Vattenfall provide access to the European Offshore Wind Demonstration Centre
Source: Vattenfall

The focus on developing new ways to optimise operations and maintenance (O&M) activities in the offshore wind segment is growing fast. Chris Hill, Operational Performance director at the UK's Offshore Renewable Energy (ORE) Catapult, a leading technology innovation and research centre for offshore wind, wave and tidal energy, sees new ways of reducing these costs coming from all angles.

"O&M together comprise almost 25% of the lifetime costs of wind farms in UK waters, so there is a significant opportunity to continue to drive down costs and improve health and safety through innovative new products and services that increase remote operation in areas such as robotics, autonomous systems, machine learning and artificial intelligence, for example," said Hill.

ORE Catapult has so far worked with over 800 companies and is accelerating the creation and growth of the UK's offshore renewable energy sector. With dedicated facilities and research and engineering capabilities, it works with both new and established UK companies focusing on diverse systems from subsea electrical cables and novel turbine blades to inspection robots and turbine control software.

"We must continue to innovate to meet the challenges of the future – bigger turbines, new foundation designs, and the adoption of novel operations and maintenance activities, as well as ensuring our future grid is optimised for our future energy systems are exciting new frontiers being explored. We also need to make sure that we develop a strong, competitive supply chain of businesses providing the innovations, products, services and exports needed to support the growth of the sector," added Hill.

ORE Catapult has supported countless new technologies across the entire spectrum of offshore wind farm design, installation, operations and maintenance. These include the RADBLAD (In-Service X-Ray Radiography of Offshore Wind Blades) and BladeBUG robots for monitoring stresses on wind turbine blades, which are being developed using ORE Catapult's robotics and autonomous systems testing and validation facilities.

In the subsea sector, ORE Catapult has been part of Marynsol's development of a software package that automates the acquisition, processing and reporting of marine survey data across a variety of autonomous vehicle platforms, while Rovco is leading the way in 3D computer vision and artificial intelligence technologies, using autonomous and remotely operated vehicles as part of the system.

Digital technology is central to many of the Catapult's projects, with the System Performance, Availability and Reliability Trend Analysis (SPARTA), Wind Energy Benchmarking Service (WEBS), and the Platform for Operational Data (POD), all delivering new ways to manage, analyse and leverage the power of data generated by individual turbines and across wind farms.

Condition-based approach to bolt maintenance

EchoBolt, a technology that uses ultrasonics to test the tension on the bolts that hold wind turbine structures together, is one of the latest initiatives to be backed by ORE Catapult (as well as development partner GE). It is the brainchild of Peter Andrews, who came up with the idea after working as a wind farm O&M manager and then founded Energy Integrity Services to support the industry in driving down its maintenance costs.

"The cost of energy from offshore wind has reduced dramatically over the last five years, putting efficiency pressure on all aspects of the lifecycle," said Andrews. "O&M costs through life can be as much as the initial capital outlay so it is imperative we look for opportunities to innovate and continue to improve. Major challenges include evolving our maintenance practices away from routine human interventions to data-led targeted maintenance interventions where necessary. This becomes increasingly important as wind farms move further offshore and machines increase in size as the cost of logistics to deliver maintenance increases dramatically."

EchoBolt aims to change the current practice that requires technicians to scale wind turbines in hazardous conditions, ›

The Oceanic Platform of the Canary Islands (PLOCAN) is one of five Watereye research partners, including SINTEF and Flanders Make

manually loosening and retightening as many as 1,000 bolts per turbine.

"Wind turbines are assembled using a large number of very sizeable bolted connections, the management of which is critical for the long-term structural integrity of the turbine. Management of these connections is one of the biggest ongoing maintenance tasks requiring a large amount of resource and downtime," said Andrews. "There are 10,429 wind turbines (offshore and onshore) in the UK, equating to an estimated 10.5 million bolts that are critical to the integrity of wind turbine structures. Having to use heavy-duty hydraulic wrenches makes this mammoth task even more time-consuming and high-risk."

By contrast, EchoBolt is a handheld device: it does not require the bolts to be loosened for testing, reducing time spent offshore for technicians. Using ultrasonics, it records sound echoes within bolts, which provides data to operators on when the bolt will need retightening. By being able to predict maintenance, operators will be able to reduce the cost of crew deployment as well as pre-empting bolt failures than can lead to critical incidents and turbine downtime.

"We developed EchoBolt to give wind farm operators the option to transition to a condition-based approach to bolt maintenance, significantly reducing the cost and safety risks associated with managing the structural integrity of wind turbines," Andrews said.

Detecting corrosion

EchoBolt demonstrates that the development of single-task remedies can generate tangible cost savings for offshore wind farm service. It is just one of several new developments addressing the intrinsic link between O&M costs and the overall cost of offshore wind energy, particularly in the face of ambitious wind power generation targets in the short and medium term.

Another promising initiative is under development at the Watereye project, sponsored by the EU and part of the Horizon 2020 call with a budget of EUR 4.7 million. It started in November 2019 and will run until the end of October 2022, with the goal of reducing the high cost of maintaining offshore wind towers that require periodic inspections.

According to Ainhoa Cortés, who together with her colleague at the Spanish non-profit research centre CEIT, Andoni Irizar, founded the Watereye project, "the highest criticality (in the cost of kWh) in offshore wind is caused by structural failure that mainly occurs due to corrosion processes non-adequately predicted nor monitored." The Watereye consortium is formed by the Cobra company (an operator of offshore wind farms), Semantic Web Company (data management) and Delft Dynamics (drones) and five research centres, including project coordinator CEIT. The team is designing an integrated set-up that will allow wind farm operators to predict future maintenance needs accurately using an aerial drone, thereby reducing operating and maintenance costs and increasing the amount of energy produced annually by offshore wind turbines. The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 851207

"Our solution aims to detect uniform corrosion, but also localised corrosion related to cracking, also with some link to the dynamics of the structure," said Cortés. "The corrosion process can be caused by a combination of environmental conditions, and cracks can also appear due to fatigue related to the load of some critical parts. Therefore, it is important to analyse and forecast environmental conditions of the specific use case and scenario such as temperature, salt concentration, oxygen levels, relative humidity levels, UV levels, hours with immersion in water."

The objective is to reduce the periodic visual inspections currently needed to analyse the health of the wind turbine tower structure, using an unattended and low-cost system capable of monitoring large structures with high accuracy.

An advanced monitoring system will enable the remote detection of corrosion levels at the most critical points of offshore turbine towers – the atmospheric and splash zones. In addition to measuring corrosion levels, the system will be able to calculate the speed at which corrosion will propagate in the monitored areas. To monitor corrosion at a set of points, the measurement system will be incorporated into a drone equipped with a very precise positioning system. This system will measure the areas with the most corrosion and then wirelessly send the data to a base unit installed in the wind turbine itself.

In addition to designing a low-cost, low-weight and low-power consumption measurement system, researchers will develop corrosion models that will process the measurement data such that the system will have the ability to learn and predict the state of the structure based on the corrosion data and other environmental parameters monitored in the tower. All the information collected will be used to run a diagnostic process which, when combined with a control system that limits the loads in the structure, will help wind farm operators to make the most efficient decisions regarding maintenance planning and overall wind farm control.

"Watereye data feed the corrosion models, diagnosis and prognosis algorithms to calculate the corrosion degradation rate and be capable of estimating the remaining useful life of the critical points of the structure. Watereye aims also to provide sophisticated control algorithms to limit the load of the tower, taking into account the current state of the structure," added Cortés.

"Ultimately, the maintenance will be scheduled in a more efficient way at the wind farm level with the accurate prediction of the health of the structures of each wind turbine."

Considering that the need for wind farm deployment in deeper waters and farther from shore will only increase O&M costs, developments like EchoBolt and Watereye are vital to sustain the downward trend in the cost of power generated by wind turbines. Many factors come into play, but if reducing the 25% portion of lifecycle costs attributed to O&M by just a few points can be achieved, the balance between cost and the benefits of clean, renewable energy will continue to tip further in the favour of more offshore wind and fewer coal or gas power plants.