The Importance of Corrosion Protection on Offshore Wind Farms

By Colin Pawsey

The offshore wind sector is facing a problem when it comes to corrosion. Wind farms are designed to operate in harsh marine conditions for a lifetime of 20-25 years. It is essential for cost of energy that turbines are able to see out this life expectancy, and any ongoing repairs must also be factored in to the overall cost. The aggressive nature of salty seawater, combined with storms, rain, hail and snow, create a particularly harsh environment, and some unforeseen corrosion problems have already been recorded on existing wind farms.

The vast majority of wind turbines in operation in Europe today are supported by steel monopile towers. Due to its high iron content, steel is particularly prone to rust, and estimates suggest that the equivalent of a quarter of the world's annual steel production is lost to corrosion each year. As wind turbines become larger, and move further out to sea in more testing conditions, where repairs are more expensive, robust corrosion protection is crucial to the continued safe operation of turbines, and the overall cost of energy.

Problem areas

There are three particular zones that the industry has to consider when it comes to protection against rust: The Atmospheric zone, which is the part of the turbine structure above the water line; the splash zone, which is the area around the surface of the water where the support structure is exposed to both water and oxygen; and the underwater zone, where the substructure is fully submerged in water. Each of the zones requires a different type of protection, and the structure should be protected both internally and externally.

The image below shows severe corrosion of an offshore tower support structure close to the splash zone.

Source: Galvinfo.com

Potential issues caused by corrosion

Many of the first monopile foundations used with offshore turbines were constructed with no internal protection against corrosion. This was partly for cost-cutting reasons, but also because it was thought that the airtight compartments would starve the area of oxygen and prevent corrosion. It has since been found that this technique is not reliable, and those early turbines may need to be examined and monitored in the future for potential damage.

Corrosion could cause substructures to become unsafe, requiring expensive repairs or in worst cases, decommissioning. At a time when the focus of the industry is on maximizing the service life of turbines, it is a serious issue. While lessons have been taken from the oil and gas industry in terms of corrosion protection, it has become apparent that the guidelines for those industries are not suitable for monopiles, and the industry is already beginning to come across problems on existing wind farms.

Maintenance and repairs

In 2012 excessive corrosion was found in the monopiles of 54 turbines at the Lynn and Inner Dowsing wind farms off the Lincolnshire coast in the UK. Operator of the wind farms, Centrica Energy, had developed its GenerationSafe initiative after a spate of health and safety issues during the same year, and used the Foundation Corrosion Repair (FCR) project as a test case for its 'one team' health and safety culture.

The repairs were carried out during 2013 and were a success in terms of health and safety, with the project being completed under budget and with fewer incidents. These repairs were not the first on the wind farms, as in 2011 Siemens carried out precautionary repairs to the 54 3.6MW turbines installed at the site.

Lynn and Inner Dowsing Wind Farm. Source: Nexans

The work was related to potential issues with the corrosion protection in the bolt holes of some pitch bearings on the turbines, which had previously been detected on land-based machines. Initially it had only been expected that Siemens would carry out repairs on its turbines at the Burbo bank wind farm, but one set of bearings was removed from Lynn and Inner Dowsing and sent to a laboratory for inspection. This prompted Siemens to exchange the pitch bearings on the other 53 turbines on site. This preventative maintenance is carried out by removing the turbine blades temporarily so that the replacement work can be performed on jack-up vessels. Since that time, Siemens has updated the corrosion protection in the bolt holes, and no maintenance is expected to be required on more recent or future projects.

Siemens are not the only company to have suffered because of corrosion, and as far back as 2004 Vestas had to carry out replacements of transformers and generators at the Horns Rev wind farm – then the largest in the world – due to an underestimation of the aggressiveness of the open sea environment and a lack of adequate corrosion protection. While more recently reports are circulating that SSE’s Greater Gabbard wind farm is undergoing retrospective corrosion protection.

Protection systems

There are several issues at play as far as corrosion is concerned. The wind industry is still in its infancy, and although lessons can be learned from the gas and oil industries, there is a need to develop industry-specific standards and best practices. The different zones of the turbine and structure require different types of protection, and these must be considered as an integral part of design, rather than an afterthought that has been included in the coating process.

The inner section of the monopile and the outer section in the atmospheric and splash zones can be treated with special anti-corrosion coating systems, while the subsea section can use cathodic protection systems in the form of sacrificial anodes or impressed currents.

Coating systems alone, however, are not enough to guarantee protection from corrosion, and several other factors must be taken into account. The severity of the environment at sea is vastly different to that on land. Offshore turbines are exposed to humidity with high salinity, intensive influence of UV light, wave action and the presence of a splash zone, and high corrosive stress which can speed up corrosion in vulnerable areas. The difference in severity is highlighted by the mass and thickness loss of low-carbon steel and zinc in the first year of unprotected exposure. For example, in Germany, onshore corrosivity is evaluated at around C3, according to ISO 12944, which corresponds to a thickness loss of 25-50 µm. In splash zone areas a thickness loss of up to 500 µm has been observed in the first year of service alone.

The EN ISO 29144 standard, part 5, German issue, states that there are nine factors that contribute to the durability of a coating system, including the design of the structure, the design of edges and weld seams, the workmanship of the applicator, the condition of the steel before surface preparation, and the exposure of the paint system immediately after application. Key areas of the structure which are most susceptible to corrosion, such as edges, weld seams, and bolt holes, must be given extra consideration throughout the design and fabrication stage, to ensure the coating is effective long-term.

Monitoring systems

While effort must be made to develop better protection from corrosion, monitoring systems will also be key to maintaining the long service life of turbines by reporting damage and problems at the earliest opportunity to reduce the cost and downtime of repairs. At the EWEA event in Vienna in 2013, BruWind (Brussels Wind Energy Research Institute) presented its monitoring solution for offshore turbines, which uses a number of sensors gather data and analyze their structural strength.

The monitoring system is designed to gain insights to help minimize construction and installation costs, extend the lifetime of offshore structures, and reduce their operation and maintenance costs. The organization is currently performing several monitoring campaigns at the BelWind offshore wind farm which has 55 Vestas 3MW turbines supported by monopile foundations. The corrosion monitoring part of the system allows for the continuous monitoring of corrosion rates, corrosion potential, and oxygen concentration inside the monopile.

These systems will be crucial to the offshore wind farms of the future, particularly as we move into deeper water with new types of foundations about which very little data has been gathered in terms of corrosion resistance and protection.

Summary

The speed at which the offshore market has developed means that it is almost inevitable that the industry will encounter problems and challenges as it progresses. There have already been issues with corrosion in various wind farms, and it is clear that the industry needs its own standards and practices, and cannot rely on transferring knowledge from the onshore wind industry or the oil and gas industries alone.

The problem of corrosion is a complex one, and it involves many parts of the design and fabrication process, and therefore several different parts of the supply chain. From initial design, through manufacturing and coating, to operation and monitoring systems, corrosion protection must be considered at each stage to develop a process that results in a robust anti-corrosion system for the next generation of wind farms.

About the Author:
Colin Pawsey is a freelance technical journalist, focusing on new trends and technologies in the renewable energy and automotive sectors. He is a regular contributor and writing consultant to IQPC and Automotive IQ, and is also the founder of copywriting agency – Pure Copy.

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