Fixed vs. Self-Installing Offshore Wind Substations

As offshore wind farms are located further and further from land in deeper and deeper waters around the world, the construction and installation of substations to support these wind farms becomes increasingly more complex and expensive. In light of this challenge, engineers and scientists are experimenting with new and inventive methods for designing and implementing substation installation in order to reduce costs, minimize environmental impact, and shorten the time required from contract signing to commissioning.

What they've developed are several innovative solutions include self-installing substations and even floating substations. Yet despite the advantages of choosing these advanced substation designs, many companies continue to opt for the known quantity of fixed designs. The debate over which system will win the day continues.

Overcoming the Downsides of Conventional Fixed Substations with Self-Installed Designs

There are several challenges with the installation of conventional fixed platforms that are designed with jacket and topside. To start, the installation and lifting only possible during times when sea conditions are ideal. For many projects in European regions, this means installation is only possible during May through September.

A second downside to conventional platforms is the fact that installing them requires ever-larger crane vessels – ships that must have the capacity to lift stations that can weigh 10,000 tons or more. Not only do these larger crane vessels cost more the larger they get, they are also in short supply. As such, availability can often delay projects further. Finally, conventional platforms for offshore substations are often designed only for shallow water conditions. As wind farms are installed in deeper and deeper waters, this creates significant challenges for the industry.

Because of these drawbacks of conventional substation design, the jack-up self-installing or floating platform is becoming more popular. There are several advantages of this alternative over conventional fixed platforms, but the most important is that they are not installed by crane but instead are floated into place. From there, the legs are lowered into place. By avoiding the cost of the large crane vessel, the installation of these types of platforms can cost less.

One of the big players in the self-lifting substation is Siemens with their Wind Power Offshore Substations (WIPOS) solutions. Designed so that the substructure is installed just beneath the surface of the water, the system is equipped with six guide pipes for the purpose of anchoring the substation to the sea bed. These piles are embedded for the trip out to sea, and then driven into the seabed once at the installation location.

Once in place, steel legs inside the six hydraulic towers are positioned exactly above the pipes. They're then threaded into the pipes and the platform is then ballasted and lowered. A special liquid concrete is inserted into the system to provide a solid connection between the topside and the base frame.

From there, the hydraulics push the topside to the planned height. Once installed, the only thing above the water is the topside cable tower in the center of the structure.

This system was recently used for an installation in the North Sea. The substation was estimated to require 750,000 production hours for installation of the first platform. Weighing 17,500 tons, even the largest floating crane in the world with a lifting capacity of 14,200 tons would not have been capable of putting this platform in place.[i]

ABB has a similar self-installing platform that they have developed with Aibel, a Norwegian offshore engineering firm. Their self-installing gravity-based structure (GBS) platform is based on designs used in the oil and gas sector. The platforms are constructed onshore and fully commissioned there, then towed into position with tugs and then secured to the seabed by using the platform's own weight and ballasting.

By using this approach, the company is able to reduce the weather dependence of installation and minimize offshore hook-up works to minimize offshore commissioning. This approach has the added benefit of reducing the need for seabed preparation, which can limit the environmental disturbance of platform installation. The design also makes these platforms easy to decommission and remove. However, one downside to these systems is that they are meant for shallower waters of 15 to 45 metres.[ii]

Alstom has a similar structure – their grid offshore self-floating, self-installing platform. It's designed with cable guides, a large pontoon, transformer and substation equipment, and protective systems to keep out the elements. The structure is assembled onshore and then floated out to sea.

Globe Tech I

Because of its self-installing design that's crane-free, it requires less time to install. Additionally, it's put in place without the use of ramming that harms marine life, making it an environmentally-preferable solution. This system was selected for use in Global Tech I (GTI), a 400 MW offshore wind farm in the North Sea of Germany.[iii]

Are Artificial Islands and Floating Offshore Wind Substations the Answer?

Perhaps even more interesting than self-installing offshore wind substations is the idea of a floating substation. This is the technology the Ministry of Economy, Trade, and Industry in Japan will be trialing in an installation off the coast of Fukushima by the end of March 2016. Known as Forward (Fukushima floating offshore wind farm demonstration), the project will be delivered by a consortium of 11 companies with the aim of testing a variety of technologies for floating wind farm structures.

Knowing that floating technologies create higher costs, the project aims to design commercially-viable alternatives with lower weight designs using less steel. As the world's first floating wind farm, this project has garnered much attention.

Since Japan's coastline has very few locations that can accommodate large fixed-foundation installations with water depths falling precipitously from shore, the perfection of financially feasible offshore floating technologies could prove significantly important for Japan's future energy mix. They aim to have the first floating substation installed by Japan Marine United (JMU) this summer, with additional installations through 2014.[iv]

A floating offshore wind turbine in Japan - the world's first

If successful, this demonstration project could have wide implications for offshore wind turbine and substation installation. The same types of technology could be highly useful in similar regions such as that in Maine of the US and Portugal where sharply declining seabeds make installations far from shore extremely difficult.

Another innovative approach to the installation of offshore wind substations is the artificial island. In Elia, the country's power grid operator, will be heading up the project to construct a doughnut-shaped island in the North Sea, about 3 km off the Belgian coast.

With a reservoir in the middle, the artificial island will store wind energy by pumping water out of the hollow in the middle when energy supply is higher than demand. Then the water would be let back into the hollow through turbines when demand rises, generating a form of hydro electricity. It's an innovative concept that will take five years to build but may solve some of the energy storage problems that the wind energy industry faces today.

The Risks of Self-Installed Substations Weighed Against Reliability of Fixed Alternatives

Despite the benefits offered by self-installed substations for the wind industry, there are those who are less enthusiastic about the concept given the inherent risk of floating a completed substation out to sea. The industry has still to garner enough experience with the technology to be able to deploy these types of systems with any degree of confidence. Though the cost savings may be big, if something disastrous happens on such an installation, costs could explode, completely eliminating the cost advantage offered by this alternative.

As such, some companies continue to opt for fixed substructures for their substations. For instance, E.ON recently awarded a contract for the design and fabrication of the substation for the Humber Gateway offshore wind farm in the UK

to Harland and Wolff. The plan is to use a jacket and pile design for the 1,300 ton substation which is set to supply enough power for 170,000 homes in the UK.[v]

Continuing Developments Needed to Advance New Substation Designs

Companies large and small have struggled with the costs of offshore substation installation. Time delays and technical challenges drive up expenses and extend deadlines. Even Siemens, the engineering giant, recently reported losses of €500 million because of the fact that they grossly underestimated the costs of building and installing substations for offshore wind projects in the North Sea in Germany. This resulted in writedowns that contributed to the company's earnings dropping by 27 percent for 2011-2012 relative to the prior fiscal year.[vi]

Though self-installed and floating substation designs may offer substantially shorter installation times and lower costs, they are still relatively new and will require some refinement in order to garner the market confidence they need to become the substation design of choice. Nevertheless, with intrepid companies (and countries!) attempting new and innovative design approaches, the technology and costs for advanced substations will certainly come down as safety rises.

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