Challenges for Offshore Wind Substation Design and Deployment

The quantity of energy lost during conversion from wind turbine to the grid can be absolutely enormous, making it imperative for the wind industry to develop efficient transformation and export systems to ensure the most cost-effective movement of energy from wind farms to the public system. Wind farms stand as the solution for extreme wind farm installations – the go-between for transporting electricity from wind turbines into a national grid.

Yet substation development is relatively new – with only 22 built at the time of this writing – and so very little has been standardized, leaving a lot of room for improvement. Yet if wind wants to become a leader in renewable energy, it must also become the leading force behind the development of top-notch offshore substations.

Current State of Wind Farm Offshore Substation Development

Much of the current development in wind is occurring in the UK, a region that accounts for about half of all offshore wind in Europe, followed by Germany with 25%. Though this puts the UK in a position of leading the market, with tremendous opportunities to develop industry-leading technologies and solutions for the wind industry, other countries are pushing the limits of offshore substation development in an attempt to build the best and most efficient solution. Since offshore wind substations are becoming increasingly important for overall profitability in the wind energy industry, this sector is likely to see a lot of activity in the decades to come.[i]

Different countries have grappled with issues surrounding the development of offshore substations and integration into the grid in their own ways. In Denmark, for instance, there has been a strong coordination between the wind farm and grid designers so that the grid concept was always part of the site selection. As a result, the projects in this country have been simple and relatively small, with single AC cables.

In Germany, on the other hand, there have been a few false starts. For instance, in 2006 there were projects that didn't get fully funded, due in large part to the number of projects awarded in one year. As a result, it was difficult for the tenant to get financing and certification. It was also a challenge for the supply chain to deliver because of the possibility of delays.

In Great Britain, the situation is yet different again. In this case, the developer has been responsible to build the project, and then transfers responsibility to the offshore transmission operator (OFTO), which results in a low cost financing arrangement. But because this model doesn't fit anyone's business model, there is still uncertainty about its effectiveness. What is certain is that coordination will be essential in order for Great Britain to reach their offshore wind farm goals.

Time will tell which country will develop the most effective benchmarks and laws for installing offshore substations and integrating that power into their grids. In the meantime, the field is relatively wide open.

Many Moving Parts Create Challenges for Standardized Offshore Substations Design

There are several challenges facing the development of substations for offshore wind projects. Perhaps the biggest and most impactful issue is that to date, all substations have been designed in a bespoke fashion, with each substation a custom fit for the particular project. This has resulted in a much higher cost per substation, leaving plenty of room for improved efficiencies and innovative technologies to reduce costs of this aspect of wind farm development.

Many factors must be considered when designing the structure of an offshore substation, all of which have been significant contributors to the challenge of developing a standardized design. For instance, what block size (MW) should be used, and will the substation transport the energy in AC or DC? Will the substation function solely as a transforming and exporting system or will it also serve as an offshore base for maintaining a wind farm? Should access to the base be by helicopter only or by boat as well? How will it be installed – with a self-installing system or by a large vessel-mounted crane? Will the substation contain prefabricated modules or be designed in a bespoke, integrated style? And should the system contain a skin for protection or not?

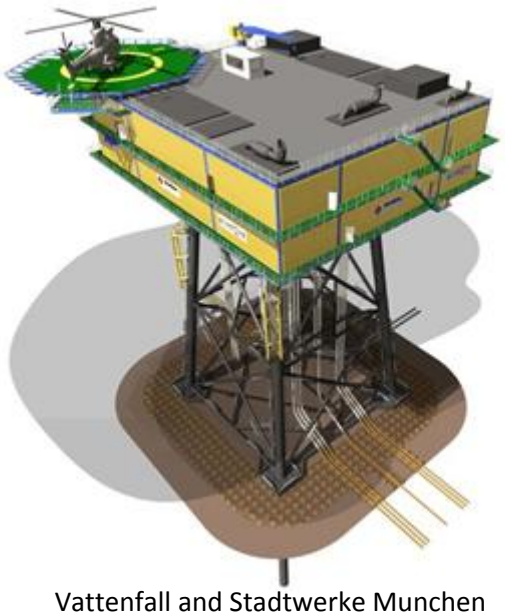
All of these questions must be answered when creating a standardized offshore substation, and they determine the speed with which it will be developed, the cost for building and installing it, and how the energy will be transmitted between turbines and onshore systems. That said, there are some general rules being followed in current design theory for offshore substations.

Industry Examples of Offshore Substation Installations

To date, industry has produced several examples of offshore substation installations illustrate the custom nature of these projects to date. Siemens, for instance, has been deploying systems for offshore substations in wind farm projects. Their WIPOS (wind power offshore substation) has several configurations, including self lifting, topside and jacket, as well as floating, all of which involve prefabricated sections with flexible configurations for both AC and DC applications.[ii]

Siemens WIPOS Offshore wind substations

The WIPOS topside and jacket solution offered by Siemens is best used where there are variable seabed conditions and are ideal when topsides are particularly heavy and/or cable connections onto the substation are complex. The base of this system is the jacket substructure which includes tubular legs and braces for strength. In the topside are the main voltage electrical equipment, personnel and equipment support facilities, and other customizable main components.



Vattenfall and Stadtwerke Munchen Offshore Wind Farm DanTysk

Another new wind park substation installation that has come underway is the DanTysk offshore wind park project run by Vattenfall and Stadtwerke Munchen (SWM) in the Netherlands. This substation will collect energy from 80 different wind turbines as the hub for onward transport of electricity via a submarine cable to the transfer station in Germany.

The substation will be constructed of two main parts, including the topside and the jacket. The topside will house the technical systems, which will be supported by the steel constructed jacket which will sit on the North Sea bed. This substation will measure 75 meters in height and weigh 3,200 tonnes, which is equivalent to 2,300 mid-sized vehicles. With a total capacity of 288 MW from the wind park, this substation will funnel energy to the grid for the equivalent of 400,000 German homes.[iii]

Ramboll is another player in the offshore substation development market. They recently completed an offshore substation installation off the shore of Denmark for the Anholt offshore wind farm, which is operated by the Danish energy provider Energinet.dk and owned by the Ministry of Energy and Climate. When designing this substation, several challenges had to be overcome, including uneven seabed conditions, high risk of ice loads during winter months, and heavy ship traffic.

This substation is designed with a topside consisting of a central area that holds three main transformers and 220 kV GIS switchgear, as well as auxiliary equipment. On several levels of the topside, there are decks that hold equipment for high voltage transmission and distribution, as well as emergency generators, batteries, and panels for wind turbine control. This substation will import energy from 33 kV radial cables from the wind turbines and transform it and export it onshore via 220 kV cables connected to the national grid.

This substation is the first to be developed in compliance with the DNV-OS-J201 standard for Offshore Substations for Wind Farms which will become one of the future standards used for European offshore wind farms. It will provide 400 MW of energy from a 111 wind turbines which will be enough energy for 400,000 households or 4% of Denmark's total power consumption.[iv] Construction on the substation culminated in the hoisting of the 1,600 tonne heavy top section into position with the assistance of a Dutch crane vessel on April 6, 2012. The substation is to be operational by August 1, 2012.[v]

The Importance of Standardization for Offshore Wind Substation Development

Timing of installation is perhaps one of the biggest challenges of the bespoke-nature of offshore substation design to date. In general, it is most cost-effective to have a substation online before or by the time a wind farm comes online in order to achieve maximum energy return on investment for each installation. This is important because a single lost day of earnings for a

wind farm is equal to 1% of the total substation capex.[vi] Uncertainties over grid readiness also have implications for the risk and cost of finance for a wind project. However, the build time for grid connection is usually much longer for wind power than other power options, so timing is one of the challenges faced by the wind industry. Standardization of design would make installation not only quicker, but more cost effective.

There are other clear benefits for the industry if standardization for offshore wind farm substations can be developed. In fact, some experts, including offshore wind energy guru Matthew Knight, head of business development at Siemens' Transmission and Distribution division, estimate that the cost of electricity transmission could be cut by a full third if substation design and deployment were standardised.[vii] According to Knight, the key to achieving such savings would be to develop and mass produce substations at a set size. By building in blocks such as 300 MW and 500 MW, it would significantly help the industry supply chain to predict demand and improve efficiency of transmission technologies.

Images via Siemens and Strukton

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Sources:

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[i] Shankleman, J. (2011, October 27). *Siemens reveals plan to mass produce offshore wind farms*. Retrieved from BusinessGreen: http://www.businessgreen.com/bg/news/2120228/siemens-reveals-plan-mass-produce-offshore-wind-farms

[ii] *Grid Access Solutions*. (n.d.). Retrieved from Siemens: http://www.energy.siemens.com/hq/en/power-transmission/grid-access-solutions/wipos.htm#content=Description

[iii] *Germany: Vattenfall Starts Construction of DanTysk Substation*. (2012, March 19). Retrieved from offshoreWIND.biz: http://www.offshorewind.biz/2012/03/19/vattenfall-starts-construction-of-dantysk-substation/

[iv] *Substation Design for Anholt Offshore Wind Farm*. (n.d.). Retrieved from Ramboll: http://www.slideshare.net/pbnrambollcom/substation-design-anholt-offshore-wind-farm

[v] *Denmark: Anholt Substation Scheduled for Operation on 1 August 2012*. (2012, May 3). Retrieved from offshoreWIND.biz: http://www.offshorewind.biz/2012/05/03/denmark-anholt-substation-scheduled-for-operation-on-1-august-2012/

[vi] Knight, M. (2011, December 6). *Connecting offshore wind: Lessons so far and future challenges*. Retrieved from Siemens Energy: http://storbritannien.um.dk/en/~/media/storbritannien/Documents/Trade%20Council/Siemens.ashx

[vii] Shankleman, J. (2011, October 27). *Siemens reveals plan to mass produce offshore wind farms*. Retrieved from BusinessGreen: http://www.businessgreen.com/bg/news/2120228/siemens-reveals-plan-mass-produce-offshore-wind-farms