Overcoming Offshore Wind Transmission and Distribution Challenges

While the wind energy field is growing, maximizing the potential of the industry will require refinement of the transmission and distribution systems used to get energy from offshore to land. Some of the practical challenges of wind energy include improper connection because of the surrounding environmental factors, regulation and integration of energy, and interconnection of the grid to large offshore wind farms. Grid stability has been and remains a huge challenge in the integration of offshore wind energy, but many companies are innovating to create effective, financially-attractive solutions to these problems.

Planning in Offshore Grid Development

European wind power generation is both economically and technically feasible. The European Wind Energy Association (EWEA) hopes wind power capacity in Europe will increase substantially by 2030, with a total projected GW output of 230 to 265 GW by wind in 2020 if all goes as planned.[i] However, in order for this to be feasible major changes will need to be made in connection requirements for wind power plants, grid infrastructure, generation adequacy and the operation and design of the actual power systems. EWEA has developed a 10 year development plan and also network codes that would provide input based on examination of both policy and technical aspects.[ii]

It's important that the grid connection requirements reflect both the needs of the technical aspects of operation and also the cooperation of the wind energy sector, public authorities and TSOs. Upgrades will need to be made to the grid infrastructure across the board. These needs will accommodate the increased amount of wind power, but will also enhance the security of the energy supply. Both long term and short term measures are being considered. Short term measures will include the optimization of current infrastructure as well as adaptation of the grid's network management procedures.[iii]

Many countries are approaching the problem of grid connectedness a little in their own unique ways. For instance, the Dutch-German transmission grid operator, TenneT, has recently hired ABB to connect the offshore North Sea wind farm, named Nordergründe, to Germany's mainland grid. This connection will supply AC current power transmission links, with a capacity of approximately 111 MW of wind power, which will be enough to server over 100,000 homes and will also save half a million tons of carbon dioxide every year. This clean wind energy will be replacing energy generated from fossil fuels.[iv]

The company ABB will be in charge of installing as well as designing the 155 kV submarine cable and land cable systems. This will also include offshore and onshore shunt reactors, onshore 155/220 kV transformers and an extension of the current 220 KV substation.[v]

Spain has set a great example of innovative grid connection problem solving. Spain has improved their integration of wind energy by allowing the TSO to operate the system with real time operation.[vi] This improves the integration of wind energy and paves the way for grid code upgrades that will regulate requirements for interconnection and the next generation operational characteristics.[vii]

Challenges with Interconnection of Grids

Whether a wind farm or turbine is being developed or has already been built, there are common challenges that arise with the interconnection of the grid systems. As a result, there has been an incredible amount of innovation and research done in order to integrate grid systems more efficiently.

A popular choice of NR Electric Co., Ltd. is Static Frequency Converting Systems. These systems are essential for the modern multi-MW class hydro generator, synchronous motor and gas turbine. What it does is influence the frequency of the interconnected power grid by providing varying frequency in order to reduce the inrush current[viii] which influences the actual frequency of the power grid. Furthermore, the Static Frequency Converting System provides a variety in frequency, increasing it from 0 Hz up to 50 Hz efficiently in order to reduce the inrush current.[ix]

Another common problem with the interconnection of offshore wind with electrical grids is the regulation of the annual energy production. The company ABB utilizes doubly-fed induction generators (DFIG) in specific cases where variable speed units are being generated. The design of doubly-fed induction generators uses a series of voltage source converters to supply the wound rotor of the machine. The rotor circuit is then operated with a variable AC frequency. This enables the machine's mechanical speed to be controlled.[x] The net power of a doubly-fed induction generator is a combination of power coming out of the stator of the machine and power from the rotor and also through the converter directly into the system.[xi]

Similar to ABB's doubly-fed induction generator, NR Electric Co., Ltd. utilizes a dual fed converter system for better wind energy generation. The idea behind this innovative technology is to regulate the doubly-fed rotor for a wind energy plant.[xii] The NR Electric dual-fed converter system provides real time regulation of both the active and reactive power. This helps to enhance the actual production rate of each wind turbine. Controlling the active power can optimize an individual wind turbine's rotate speed. Controlling the reactive power helps to adjust the overall system power factor. All together this improves the dynamic stability and steady state of the system as a whole.[xiii]

GE Electric is also integrating new innovations for better interconnection for both wind and solar generation. GE has anticipated the increased demand that the offshore wind energy industry and has provided Smart Grid products and services in order to stay ahead of the curve.[xiv] The overall goal of the Smart Energy products is to increase power grid reliability. GE does this by ensuring safe interconnection of wind generation and also by facilitating faultless transfer to wind energy backup power systems.[xv]

One product that it's a useful innovation in wind energy is GE Distributed Generation (DG). This innovative technology allows the safe connection of the DG to a wind farm's grid. It acts as a two-way wireless network which emits emergency disconnect signals from the utility site to the distributed generation sites. Once signals are received, a confirmation status is then returned to the control center of the wind farm. The DG products offer an innovative, easy solution that also reduces the cost of communication while ensuring a reliable interconnection to and from the grid.[xvi]

The Debate Between AC or DC for Interconnection

While there are many different types of technologies being used for power interconnection, AC systems are the most common. Recently, varying characteristics of individual wind turbines and long distances have required improvements on AC systems. One new innovation in AC systems is the Flexible AC Transmission System Technology or FACTS. This makes controlling AC transmission interconnection systems simpler and also more energy efficient.[xvii]

What FACTS does is enhance an AC transmission system by increasing the power transfer limit. It does this by introducing electronic devices to the existing AC system in the right places at the right time.[xviii] FACTS devices have been utilized in the state of New York successfully in recent years. The generation of wind energy is utilized in the northern and western sides of the state while the load centers are in the eastern and southern areas of New York, making efficient long-distance connections critical.[xix]

While AC has been the common choice for transmission of electricity, DC transmission is starting to emerge as a big competitor for popularity. High Voltage Direct Current or HVDC is today's economical alternative to AC. Not only is it reliable, but HVDC takes care of many of the stability issues AC transmission does not.

One example of the use of HVDC systems is in the southern part of the Gotland Swedish Islands where wind farms are prominent. AC transmission is not feasible or desirable in this region for several reasons, and so instead, the wind farm chose to install HVDC transmissions with 70 km of underground cables.[xx] Not only does HVDC improve the overall functionality of the wind farm, system stability has improved, voltage stability has become easier to predict, flicker problems have been eliminated, and voltage quality advanced with the increase in wind production while transient phenomena disappeared.[xxi]

While there are projects that include either AC or DC power interconnection, the are some American researchers (led by ABB) looking into the possibility of employing both AC and DC power converters for the US Department of Energy's (DOE) 20% Wind Energy by 2030 initiative.[xxii] While the US has several offshore wind turbines in place they have not been fully utilized, and so there is essentially a clean slate in terms of trying various technologies. ABB will oversee this huge initiative and will assess the delivery and collection technologies available.[xxiii]

The University of Pittsburgh will also be contributing to the DOE's project by examining both traditional and advanced delivery options for electric power. Both AC and DC power converters will be utilized in the project, along with innovative power electronics-based transmission products and also underwater cable systems.[xxiv]

Reliable Grid Connections Paramount to Offshore Wind's Success

It's clear that as the offshore wind industry expands and more of its energy is fed into the grid, innovations that smooth out the transfer will be necessary both for safety and efficiency. Yet with the substantial potential for offshore wind to contribute to the energy mix around the world, the opportunities in this sector are also extremely great. No doubt enterprising companies and research firms will continue to innovate in order to meet the challenge and profit from the exciting growth in renewables.

Images via: Flickr – Timothy Tolle (Figure 1) and OLC Fiber (Figure 2)

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