Making Wind Farms and Offshore Grids Compatible

Despite the growth of the offshore wind power sector, grid instabilities are still a problem for most countries, posing delays and challenges yet to be overcome. Creating balance between the wind load and the generation is an obstacle many companies are looking to meet head-on. While finding innovative technologies to increase grid and turbine compatibility is the main focus, the need for innovative energy storage is also part of the picture for many energy companies and nations. This issue will become substantially more prominent as the size and capacity of turbines increases.

As of today, storing electricity is more expensive than using it up, but innovative thinking – like hooking hybrid electric vehicles into the grid as storage units for offshore wind - could achieve the massive MW of storage needed for the overall electrical power system.[i] Many other interesting advances are being made to make wind farms and offshore grids integrate much more smoothly.

Active Power Based Control to Minimize Short Term Output Fluctuations

A primary problem for offshore wind in terms of grid compatibility is the short term output fluctuations. Basically, changes in wind speed cause changes in rotor speed and when connected to a grid, short term fluctuations such as these cause energy flickers, which can be problematic. This is where active power based controls can be used to minimize fluctuations.

A large 2 MW turbine in Japan utilizes new innovative technology developed by Hitachi and Fuji Heavy Industries Ltd. to help minimize output fluctuations by using active power based control. The active power based control helps to generate a steady level of electric power output specified by commands. Hitachi has been able to generate a grid friendly wind power system through its innovative technology and minimize the disturbances that can commonly happen in grid power systems.[ii]

Another important feature Hitachi included in their system to help minimize short term output fluctuations is the use of a downwind design – effectively the rotor of the system is installed on the downstream side of the turbine. This is an unusual design considering most larger offshore wind turbines have an upwind configuration with the windward side being used for the rotor.[iii]

This innovative design helps to provide both a stronger and safer system while also lightening the load on the key mechanisms that can fluctuate with gusts of winds during storms and typhoons. This type of system is also great for utilizing those offshore and onshore wind systems that are on steep terrain or on mountainous sites.[iv]

Doubly Fed Induction Generators (DFIG) for Greater Stability

Another problem for offshore wind is grid incompatibility which can cause many problems for system operators, including grid output balance, voltage variations and just overall grid instability.[v] As a result, many countries are seeking the use of Doubly Fed Induction Generators (DFIG) in order to balance the system with the grid. DFIG's today are most often installed with Fault Ride Through capabilities to create more reliable systems.

Wind turbines and farms that are connected to voltage above 100kV transmission systems must stay connected even when a voltage dip occurs inside the grid.[vi] This can help improve the stability of the system by isolating the wind turbine from the voltage dip, thus creating a balanced system without flickers or power losses.[vii] Both Germany and Denmark system operators have utilized the DFIG Fault Ride Through capabilities and improved upon their grid codes.[viii]

Woodward Wind Converters is a leading supplier for renewable energy generation. They provide both onshore and offshore components including Low Voltage Converters for DFIGs for large offshore wind turbines and farms.[ix] These Low Voltage Converters make it easier to integrate new wind energy plants with the grid, especially for 1.25 MW up to 6 MW turbines.[x]

Woodward's Low Voltage Converters

For those wind facilities with modular or compact designed systems, Woodward also has a Low Voltage Full Size Converters for synchronous generators in both onshore and offshore turbines and farms. Successful field tests were performed on system variations for 50 Hz and 60 Hz grids for power classes of 2 to 5 MW.[xi]

Modular Medium Voltage Full Size Converters for synchronous generators are better suited to the growing capacity of larger wind turbines and farms. Woodward's versions of these converters for 4 MW to 10 MW capacity wind turbines have been specifically designed to maintain operation through even the harshest environmental conditions, which is great for offshore wind farms and turbines.[xii]

Woodward's wind converters actively dampen dynamic torque loads in the drive train and because the gearbox is well protected. Not only is this a safety feature, but it extends the life of the system and increase its reliability. The wind converters also have an intelligence control feature that ensures proper compliance with all valid international grid code requirements at the point of common coupling.[xiii]

Innovations in Offshore Substations

Another consideration that needs to be made for offshore wind in terms of grid connectability is the update of substations. A functional substation is essential for a well run grid that's dependent on offshore wind.


Figure 1: Flooded Substation (FirstEnergy Corp.)

Siemens is one of the leaders in this field. Their Windpower Offshore Substation or WIPOS offer flexible and optimal solutions for instabilities in grid and turbine systems. WIPOS combine the topside substation configuration with a multi-deck construction,[xiv] as well as foundations that are sufficient for withstanding various tide and seabed conditions and also a variety of offshore weather. Depending on the project the foundation can be one of the following three: topside and jacket solution, floating solution, or a self lifting solution.[xv]

Reliability is a key factor for compatibility between wind energy projects and their grids. As such, once a Siemens substation has been designed, the WIPOS solution is put through several sequential processes to ensure reliability and consistency in the innovative technology.[xvi]

On top of WIPOS solutions, Siemens is also initiating a self learning software system. This self learning system is based on neural networks and is able to forecast the electrical output of wind energy sources over a period of 72 hours. It has been tried and tested and within the 72 hour time period it is 90% accurate. This ensures grids are running smoothly and accurately.[xvii]

ABB is another innovator in this field, and has partnered with TenneT to provide grid connections to offshore wind farms in the German North Sea. In 2009, ABB installed a 400MW wind farm grid for TenneT and is constructing a second grid connection, approximately 800 MW, set for 2013 with a third on the way for 2015.[xviii]

For this project, ABB will introduce a wide scale project of HVDC transmission by both subterranean and submarine cables. The systems will include complete converter stations and will convert AC to high voltage DC in one part of the system while at the other end it will have a transmission link back from HVDC to a grid code compliant AC.[xix]

In substations one of the critical factors is the full load losses. However, with ABB's innovative designed systems the full load losses are less than 1% per converter station.[xx] The inconsequential loss is in large part due to a modern upgrade in HVDC called HVDC Light, which ABB developed a decade ago in order to allow a wide scale introduction of HVDC transmission. The HVDC Light component is able to stabilize the AC voltage at the terminals. This is a huge asset to all substations especially those where the offshore wind system voltage can fluctuate rapidly due to large variations in wind speed. With the HVDC Light the 1% per converter station is assured.[xxi]

KIC InnoEnergy Smart Grids and innovative projects seek to improve offshore wind energy systems by using controllable and intelligent power components (CIPOWER).[xxii] One of their main market outputs is an innovative controllable power device for submerged marine substations. KIC InnoEnergy is also producing new devices for the switching of electric power, electrical energy conversions, and is improving their design tools for current interrupting devices.[xxiii]

Innovations are also being produced for new sensing devices that can be utilized during the monitoring of power system components. New methods are being developed for handling and detection of critical events in the power systems which include transient over voltages and short circuits.[xxiv]

The CIPOWER outputs will include the ability to extend the operating limits of all wind energy components. Updating and using the above main market outputs will increase the strength, safety and reliability of components along with the operating limits. The designs and updated grid components reduce losses in energy and enhance the overall energy quality of the grid.[xxv]

Many Approaches, One Goal

Grid stability is a problem offshore wind needs to solve, and fast. Though there are approaches to overcoming these challenges, the goal is the same: grid stability. The coming years will certainly show a narrowing of the field as companies compete to provide the most efficient improvements. The changes can't come fast enough.

Images via: Woodward (Figure 1) and FirstEnergy Corp (Figure 2)

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A student of all things green, Maryruth has a special interest in cleantech and green buildings. In recent years, Maryruth has worked as the senior editor of The Green Economy magazine, is a regular blogger for several green business ventures, and has contributed to the editorial content of not one, but two eco-living websites: www.ecolife.com and www.GreenYour.com. You can learn more about Maryruth's work by visiting her site, www.jadecreative.com.

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