Keeping Wind Competitive with Next Gen Innovations

By Maryruth Belsey Priebe

Abstract

From transportable platforms to lidar optical sensors to energy conversion technologies, innovations in the electrical and electronic components of wind turbines are making this renewable energy more competitive with traditional fossil fuels.

China, Germany, and the US lead the world in attractiveness for wind energy investments according to the wind indices developed by Ernst and Young.[i] But with subsidies like the US Production Tax Credit (PTC) scheduled to expire by the end of 2012, if wind technology doesn't prove its ability to be cost-competitive with traditional fossil fuels, it may be dead in the water. Improvements in the electronic and electric components in turbine technology hold some of the most promise for reducing the cost of wind energy while increasing reliability and improving availability.

Next Generation Turbines to Overcome Sensing Challenges

A downed turbine is a money-losing turbine, and so knowing the current status of a wind turbine at any point in time is important for achieving a high uptime record. Sensors on a wind turbine therefore are extremely important for managing the production of the machine. But there are many challenges for sensory technology on utility scale turbines, including the following:

- Determining if wind speeds are sufficient for turbine startup is often limited by location options for anemometers and the complexities of blade and wind interaction.
- Sensor failures are often difficult to detect and diagnose because of calibration errors and other difficulties.
- Traditional wind turbine technology has relied on electrical sensors, but as systems get larger (wider and taller) and more complex, so do the electrical components. When lightening strikes, there's a significantly increased potential for total system failure.

But where old sensory technologies have failed, innovative sensing systems will fill the gap by overcoming these conventional challenges.

For instance, lidar sensors, or light detection and ranging optical remote sensors, which have been traditionally used in archaeology, geology, seismology, and by NASA for atmospheric physics, are being tested in wind farm settings. Here they are being tested to evaluate wind profiles, including wind turbulence and shear parameters as well as speed and direction, an innovation that is especially useful for hurricane situations and conditions at airports. One of the benefits of this type of sensing technology is that it can be deployed with off the shelf telecommunications equipment and are based on solid-state sources, making it possible to improve reliability at a lower cost per module.

The new Optical Sensor Interrogator developed by Micron Optics is one such system. It receives, reads, transmits, and stores the data produced by a fiber Bragg grating (FBG) optical sensing system. These sensors are embedded in fiber optic cabling within the blades, and can measure 80 sensors ten times per second, thereby increasing the quantity and accuracy of the data being sensed.[ii]

The monitoring and control software can analyse the information from the system and adjust the turbine in real time to react to changes in wind speeds to reduce blade stress. The sensors also monitor and report on defects and imperfections in the blades, adjust pitch, rotate the turbine, or even shut down the entire system if necessary.

New sensing technologies allow turbine controllers to react more quickly to determine where failures originate and minimize downtime as much as possible. More data also makes it possible for farm managers to optimize turbines as they interact with one another in large installations. The next few years doubtless will result in significant sensory advances in the industry which will increase the financial viability of wind turbines at all scales.

New Innovations to Solve Offshore Wind Farm Challenges

Offshore wind installations present unique and complex challenges for the wind industry, especially where floating platforms are involved. High seas and stormy weather where turbines are located up to 300 km from the coastline make installation and maintenance of wind turbines increasingly difficult and often dangerous.

Consider that ideally, a wind turbine will operate every day of the year, but inclement weather and turbulent working conditions can seriously hamper the ability of wind farm developers to get their turbines built and keep them running year round. One study found that, with an average of only 210 possible working days per year using current technologies, the downtime of offshore turbines in the UK could amount to £3bn in lost generating revenue every year.[iii]

Assembly, installation, and decommissioning of offshore wind structures is therefore one of the primary challenges in this sector, but advances in electronic controls may significantly diminish these challenges. Of particular interest are transfer systems for personnel, equipment, fuel, cargo, and subsea equipment deployment that allow for the safe, efficient, and reliable movement of equipment and people. Systems such as robotic arms (created by Germany's Momac Offshore Transfer Systems) and hydraulic suspension vessels (developed by Australia's Nauti-Craft) use sensors to measure motion, stabilize boats and platforms, and speed transfer times.

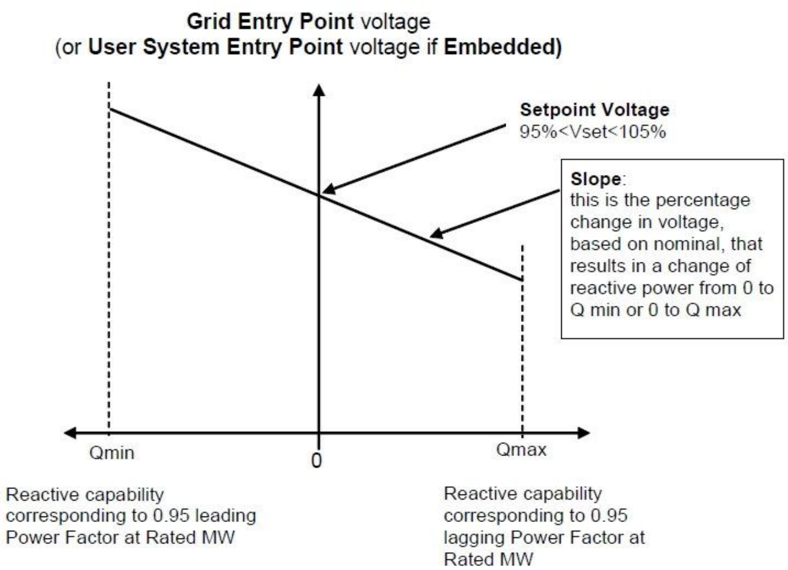
Gamesa has also developed a FlexiFit®, which is a combination crane and nacelle. This system, which relies on sophisticated software and controls, allows for easy assembly and service in offshore conditions by coupling the two components together.

The ability to move entire turbines to take advantage of better winds or to reposition for repair would be another method of addressing offshore challenges. On French company, IDEOL, is using this idea by developing a system that would allow them to relocate turbines in the water to position them for optimal wind conditions.

Overcoming Grid Code Requirements for Wind Turbines and Wind Farms

Another substantial obstacle for the growth of large-scale wind installations is the current limits in transmission capacity, coupled with an inefficient grid on most continents. A key component in the race to reduce costs for wind energy is the standardization of electronic and electric systems in order to lead to broader accessibility.

Modernization of the grid and improvements in turbine design will also lower the energy losses that occur during the transfer of wind power into the grid, which will ultimately lead to greater energy generating capacity across the industry.



Slope reference set-point range from the UK Grid Code; Image via The European Wind Energy Association

The electric grids in virtually every market must undergo harmonization and redevelopment in order to accommodate power from wind farms, both onshore and offshore. Issues around voltage control, frequency rating, power rating, and power quality all must be considered when planning for a wide scale integration of wind power plants with the overall system.

As such, governments in Europe, North America, and Asia are all working toward harmonized grid code regulations that will smooth the transition to a greater contribution of wind power to the system. As stated by the European Wind Energy Association, "The basic idea behind the structural harmonization is to establish a generic grid code format where the structure, designations, figures, method of specification, definitions and units are fixed and agreed upon."[iv]

Issues related to grid codes will create new requirements for wind turbine manufacturers and controllers, many of which can be solved by electric and electronic technological advances. Innovations in the way turbines operate and transfer energy to the grid can smooth the transition. The Rotork valve actuators, for example, were developed specifically for offshore installations to convert AC power into high voltage direct current (HVDC) for onward transmission.

Many other opportunities exist for enhancing component reliability for better integration into the grid. Improvements in components that control factors such as motion, temperature, vibration levels, and other stresses all need to be examined to find improvements that increase accessibility and reliability.

Researcher Dr. Nasiri of the UWM Research Foundation has been exploring the use of electronics and other technologies to address gearbox stress and mechanical wear, among other challenges. The ultracapacitors he is using act as energy storage elements on the DC bus of a full four quadrant power conversion system or a doubly-fed induction generator system, which ultimately helps protect the grid from the fluctuations and variations in power and voltage.

In addition to reducing gearbox stress and mechanical wear, this innovation increases efficiency by adding power conversion stages, and lowers costs due to the lower maintenance and replacement for gearboxes and generators. It also has the advantage of smoothing power for improved power system stability during transient dynamics.

Reliability of the drivetrain is also extremely important for integration into the grid, and will play a significant part in lowering the cost of wind energy, too. One of the methods being used to increase drivetrain reliability is to reduce the number of components, which will not only reduce costs but also minimize the changes of malfunction. Innovations in both geared and direct-drive systems are being made which will eliminate high-risk components, minimize expensive materials use, and optimize performance both on land and offshore. Take the Gamesa GridMate® modular electric system that enables partial operation while isolating the mechanical train from load surges which can be caused by voltage drops. These innovations together ensure that the system meets the network’s most demanding codes.

Conclusion

The opportunities for achieving greater performance from wind turbines and wind farms through innovations in electronic and electrical components are nearly countless. Determining which of these technologies offers the greatest hope for reducing wind energy costs, while increasing reliability and accessibility is a challenge developers and controllers alike are grappling with.

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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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Sources

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