Improving emergency wind pitch safety and reliability

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Renewable energy, primarily wind and solar, will represent the largest source of electricity growth over the next five years, driven by falling costs and aggressive expansion in emerging economies. Globally, progress continues to be strong with increasing annual installed capacity and investments. As solar power becomes more economical, wind systems have to become competitive to continue to grow.

Consequently, development of new technologies which reduce turbine maintenance and life cycle costs, improve reliability and lower levelized cost of energy (LCoE) will result in wider adoption of wind power generating systems.

LCoE is one of the utility industry's primary metrics for the cost of electricity produced by a generator. Key inputs to calculating LCoE include capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and an assumed utilization rate for each generator.

Wind asset operators understand that O&M costs must be minimized to maximize energy generation. Thus, turbine reliability and high energy throughput are a critical measure of wind generation.

Although all components in a wind turbine must work reliably, a turbine's wind pitch system, whether electric or hydraulic, is a key component required for optimum blade pitch control under adverse wind conditions; to maintain turbine uptime for continued power generation.

These electric pitch systems are located in the turbine hub and subjected to adverse environmental conditions such as temperature variation and vibration. Several reports indicate that among all components, pitch systems exhibit the highest percentage of failure. Improving the reliability of these systems is an important step to reduce operating and maintenance costs.

Maxwell has been actively engaged in designing ultracapacitor-based energy storage solutions to significantly enhance the reliability of electric pitch control systems, which are typically battery-based. While batteries have many useful applications, their use in electric pitch systems has presented several challenges to the asset owner.

The extreme environmental conditions in a wind turbine hub cause batteries to age rapidly; requiring regular maintenance and replacements and complex, time-consuming logistics for properly discarding battery modules.

In addition to the design and development of new ultracapacitor-based electric pitch control systems, there is now a growing trend toward retrofitting ultracapacitors for emergency electric pitch control in lieu of batteries. OEMs are installing ultracapacitors to improve turbine operational safety and reliability from the get-go, and wind farm operators are installing them to retrofit fielded battery systems.

Ultracapacitors, unlike batteries, have the ability to deliver quick bursts of power in short timeframes—an ideal function for emergency feathering control (EFC). Upon loss of main turbine power, or when high winds threaten the safety of the turbine, ultracapacitors provide the burst power needed to feather the blades to a safe position, protecting the turbine from destructive wind force. Batteries have higher electrochemical resistance and must be oversized to address the quick response

times needed for pitch control.

Ultracapacitors help improve operational safety and reliability of the emergency pitch system by contributing several advantageous features. For those readers less familiar with the technology, a high-level overview of its benefits is highlighted below.

Resiliency at low and high temperatures

Ultracapacitors operate in a much wider operating temperature range than batteries. Batteries fail to function when cold temperatures set in, and extreme heat has a detrimental impact on battery chemistry.

Ultracapacitors, also known as supercapacitors, are electrostatic devices, making the technology much more resilient to temperatures that limit battery performance. This alone is a major advantage, considering many battery replacements are due to high temperature aging resulting in performance loss.

Ultracapacitors exhibit stable capacitance and ESR (Equivalent Series Resistance) over a wide temperature range, which facilitates reliable emergency pitch control.

Long lifetime with minimal maintenance

Ultracapacitors exhibit a long lifetime especially when both voltage and temperature management is implemented in the design. Lifetime estimates are calculated based on the operational environment (temperature) which then drives design parameters (i.e. setting operating voltage to maximize product life.

Few to no replacements

Ultracapacitors require few to no replacements, thus eliminating the need for warehousing and logistics management of replacement batteries. Considering that batteries, on average, are typically replaced every four to six years, the warehousing requirement is factored into operating costs, which negatively impacts LCoE. Ultracapacitors will typically function for 15 or more years, reducing the need for storing replacement modules.

Reduced battery waste

This benefit is an extension of the last one—discarded batteries pile up over time, resulting in more battery waste that takes resources to dispose of properly. Ultracapacitors reduce battery waste that is inherent of battery-based pitch systems.

Fewer technician climbing hours

It's no easy task to ascend a turbine, especially when you consider remote locations such as offshore windfarms where technicians have to be transported via boat or helicopter. The more time required for maintenance, the more resources have to be allotted to turbine climbs. Ultracapacitors are hardy components and offer the major advantage of little to no maintenance, resulting in fewer turbine climbs and reduced risk to technicians, including the burden of transporting heavy lead-acid battery replacements.

In addition to the cost of maintenance, the turbine must be shut off during repairs, which costs the operator a few hours' worth of revenue generation. In terms of downtime due to emergency pitch control system maintenance needs, ultracapacitor-based systems offer a significant advantage over battery-based systems.

Safety

An additional benefit is that ultracapacitors can be fully discharged before being handled. This is a critical safety aspect, especially when technicians work around high voltage systems in the confined space of a turbine hub.

Ultracapacitor-based wind pitch systems have earned a reputation of contributing to reliability, increased safety and reduced downtime. Wind asset owners can reap the benefits of ultracapacitor-based emergency pitch systems when purchasing new turbines or retrofitting existing turbines to achieve pitch system safety and reliability.

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Dr. Bendale joined Maxwell in 2011 as Director of Advanced Engineering Development responsible for the design and development of Maxwell's ultracapacitors. In 2015 she was promoted to Sr. Director, Applications engineering, where she has overall responsibility for supporting ultracapacitor-based design solutions for a broad range of applications. She is actively involved in growing the wind segment at Maxwell; supporting design and integration of Maxwell ultracapacitors in electric emergency pitch systems.

Dr. Bendale has over 18 years of experience in engineering management, product development and R&D and holds several patents. Prior to joining Maxwell, she held technology management positions at Energizer in Gainesville, Florida and in the defense industry in San Diego, CA. She holds a Ph.D. with training in electrochemistry at the Yeager Center for Electrochemical Sciences (YCES) at Case Western Reserve University, Cleveland, Ohio; Materials Science and Engineering at University of Florida, Gainesville, Florida and a Certificate in Systems Engineering from the University of California, San Diego.