Operation and Maintenance Strategies for More Cost-Effective and Reliable Wind Turbine Blades

One significant factor keeping wind power from developing into a more reliable source of renewable energy is the prohibitive costs of operating and maintaining large wind turbines. Although manufactures offer warranties, these often expire after a few years, leaving turbine owners and operators to bear the cost of repairs and maintenance which become necessary over the 20-year life expectancy of a turbine blade. To deal with this ongoing problem, there has been recent research and development dedicated to making rotor blades more reliable, more cost-effective, and more efficient.

Improved Operation and Maintenance

Experts are finding that improvements to maintenance strategies and procedures can reduce overall costs and increase reliability in the blades. One of the best ways to reduce costs for maintenance and repair is simply to eliminate wait time and shipping costs. Many industry experts agree that having parts repaired locally will drastically decrease maintenance costs. Sandia National Laboratories offered this example of how overseas maintenance work comes at a great price:

> The cost for replacing a gearbox in a 660 kW turbine, on a 65 meter tower, is on the order of $120,000, for a site with local hydraulic crane service. The bulk of this cost, perhaps 80%, is for procuring and overseas shipping the new gearbox, and the remainder is for crane, site labor and local shipping. Overhauling the gearbox at a local rebuild shop can reduce the total replacement cost to around $40,000 - $50,000; these facilities are

occasionally being established in areas with high concentrations of wind power projects.[i]

Operators should develop a list of critical components, allowing them to proactively address a problem with minimal downtime. The key, they stress, is to maintain the wind turbines *before* they breakdown. As wind energy becomes more widespread throughout the country, they predict that local repair companies will be increasingly able to fix wind turbine machinery, eliminating the need for costly shipping fees and long wait times.

One of the ways that Vestas is improving operation and maintenance for their clients is by offering comprehensive on-site inspection and maintenance of turbines and blades. We spoke with Francisco Javier Martin Fernández, one of their engineers and a blade specialist, who spoke about their maintenance contracts which include on-the-ground inspections that are efficient and reduce the costs of maintenance by spotting problems before they mature.

He explained, "Our inspections are done on the ground so that stop time is relatively short. It starts by listening to the turbine. A trained inspector can identify if there are damages to the blades merely by how it sounds. Then inspectors do a visual inspection with telescopes and high definition cameras, taking pictures of all areas of the blade. We then send the data back to our specialists who understand the design, structure, and operation of blades so that they can examine the information and recommend repairs if required."

He stressed that the images they capture are extremely high resolution, "I am able to see a 1 mm wide section of the blade perfectly with these cameras. In fact, this method allows us to solve 95% of the problems that we see and we're able to determine whether something should be repaired now, in six months, or never."

He went on to say that by using specialized imaging equipment, their system reduces the need for expensive cranes and platforms that are often used for inspection. These savings are magnified the longer the blades become, especially given the extremely specialized machinery needed to reach the heights of the largest turbines being installed today.

As far as Francisco is concerned, this is just the start of the many innovative inspection techniques for better operation and maintenance that are likely to be used in the industry in the coming years. “I think we’ll be using drones in the near future, though we need to solve the problem of picture quality first. That will require improving drone stability. The other issue is reference. When taking pictures from a drone, you become lost without reference, so we also need to develop a reference system to know which part of the turbine we’re seeing in any given image.”

He also believes that future wind turbine blade maintenance will involve robotics, which will be especially useful for inspecting the interior part of blades. “Traditionally, inspectors use rope inspections, but this can damage the blades. Robots can helop avoid this problem.”

Design Strategies for More Reliable Turbine Blades

Many energy companies are already jumping into the fray, including Siemens which is optimizing their design and technology for turbine blades. Their latest innovation, Vortex Generators, are “designed to improve the flow of air over wind turbine blades and thus enhance aerodynamic performance. They do this in the so-called boundary layer, the region of flow very close to the blade’s surface.”[ii] Even Siemens admits, however, that more can be done to improve the reliability of the blades.

Another company quickly making strides is Dynamic Blade Technologies, Inc., which recently entered into a licensing agreement with the University of Wisconsin-Milwaukee Research Foundation to develop and commercialize energy-storage and power-conversion technology. Their patent-pending technology uses ultra-capacitors as energy storage, providing greater grid stability. According to the manufacturers, their technology will result in less mechanical wear on the gearbox, lower repair costs, higher efficiency, and support for power-system stability.[iii]

Sandia National Laboratories has also been heavily involved in research and development and will be hosting the Sandia Wind Turbine Blade Workshop later this year. The event brings together wind energy professionals from industries, universities, and national laboratories to deal with the challenges and find solutions for wind turbine blades.[iv]

Researchers maintain that there are ways to reduce the costs of wind turbines. One of the main factors are the blades themselves, which scientists agree can be improved through technological advances and better manufacturing. As blades increase in size, experts say that designers must take additional steps to improve the long-term reliability of blades in order to reduce downtime, which can be extremely expensive. Examples of solutions include using a more conservative design, enhancing quality control in the manufacturing process, and reducing risks by finding innovative and more reliable lightweight materials to replace fiberglass that is traditionally used to construct the turbine blades.[v]

Innovation to Lower Wind Turbine Blade Costs

The cost of the wind turbine is the single largest cost component, and can make up 70% or more of the entire cost of a land-based wind project. The cost of installation, such as construction, makes up the remaining capital costs.[vi] Although costs have been reduced in recent years, this still represents a significant financial risk for people searching for sources of renewable energy.

The Department of Energy has been working with the Blade Reliability Collaborative, which collects data from blade manufacturers and industry leaders and then organizes it for research and development. Along with the BRC, the Department of Energy has reported the following breakthroughs in blade design:

- The time it takes to produce a single turbine blade will be reduced by 37% (38 to 24 hours)
- Advanced carts and material handling systems were designed to rotate a blade 270 degrees, reducing the number of times a blade must be moved throughout the manufacturing process
- New heating techniques were developed to reduce the amount of time that composite materials take to cure
- New component handling systems were designed to aid in the installation of large, cumbersome parts
- New 3D-projected blueprints will be implemented in order to reduce the amount of time it takes for workers to identify the correct location for the

installation of fixtures and connecting hardware. These blueprints will be displayed from overhead through a unique system of projectors and lasers.[vii]

The American Society of Mechanical Engineers, while optimistic about recent developments, still maintains that advanced research must continue to ensure the development of better blades: "Research areas that are critical for the future success of the wind industry include aerodynamic design of blades, advanced approaches to control the turbulent flow around the blades, lighter and structurally more resilient materials for blades, gear box technology and power transmission systems, and energy storage technologies. The integration of advanced computational approaches with laboratory and field-scale experimentation is helping researchers understand the very complex interaction between turbulence in the atmosphere and the machine."[viii]

Moving Forward

More research is still needed to determine whether advancing technologies can help solve some of the cost problems associated with wind energy. For instance, Francisco explained his expectations for improved blade designs for the future. In particular, he pointed out that ice build-up on the blades can be a huge problem for wind farms. Not only does falling ice create hazards for workers and anyone below the blades, as the ice breaks off of an upper blade, it can fall and damage the blades below as well. He's calling for better icephobic coatings, and though there are some already on the market, none have yet to be sufficiently tested for efficacy.

However, by developing more streamlined installation, construction, and repair strategies, wind turbine operators will already be able significantly decrease their costs while increasing the reliability of the blades. These steps combined with improved innovations in the design of the blades should prove beneficial to the wind energy industry in the near future.

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Maryruth can't help but seek out the keys to environmental sustainability - it's the fire that gets her leaping out of bed every day. With green writing interests that range from sustainable business practices to net-zero building designs, environmental health to cleantech, and green lifestyle choices to social entrepreneurism, Maryruth has been exploring and writing about earth-matters and ethics for over a decade. You can learn more about Maryruth's work on JadeCreative.com.

Sources

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[i] *Wind Turbine Reliability: Understanding and Minimizing Wind Turbine Operation and Maintenance Costs.* (2006). Retrieved from Sandia National Laboratories: http://prod.sandia.gov/techlib/access-control.cgi/2006/061100.pdf

[ii] *Blades*. (2014). Retrieved from Siemens: http://www.energy.siemens.com/hq/en/renewable-energy/wind-power/wind-turbine-technology/blades.htm#content=Integral%20blades

[iii] Hunt, L. L. (2013). *Dynamic Blade Technologies licenses UWM wind turbine energy-storage technology.* Retrieved from UMW: http://www5.uwm.edu/news/2014/06/16/dynamic-blade-technologies-licenses-uwm-wind-turbine-energy-storage-technology/#.U60L0o0o9pM

[iv] *Wind Turbine Blade Workshop*. (2014). Retrieved from Sandia: http://windworkshops.sandia.gov/

[v] Yang, W. (2013). *Testing and Condition Monitoring of Composite Wind Turbine Blades.* Retrieved from World Academic Publishers: http://www.academicpub.org/amsa/file/AMSA%20Book/Chapter%20-9.pdf

[vi] *The Cost of Wind Energy in the U.S..* (2013). Retrieved from AWEA: http://www.awea.org/Resources/Content.aspx?ItemNumber=5547

[vii] *Advanced Blade Manufacturing*. (2014). Retrieved from U.S. Department of Energy: http://energy.gov/eere/wind/advanced-blade-manufacturing

[viii] Crawford, M. (2013). *Wind Turbines Get Bigger and Smarter*. Retrieved from ASME: https://www.asme.org/engineering-topics/articles/renewable-energy/wind-turbines-get-bigger-smarter

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