Innovations in Wind Turbine Blade Testing and Design

Even as wind power becomes a more reliable source of renewable energy, there are still significant factors standing in the way. Most important is the enormous cost to build, operate, and maintain wind turbines and rotor blades. Fortunately, new research is emerging that points to possible solutions through improved blade design and technological advances.

Advances in Testing of Wind Turbine Blades

First, blades are getting progressively larger, which researchers say also means that they "must be more reliable and stronger than ever before to sustain higher static and cyclic loads that are randomly applied."[i] There are a number of tests designed to determine the strength and work load capabilities of a manufactured blade. During static testing, ballast weights are hung from the blade in different areas, which tests the ultimate strength of the blade.

Fatigue testing is also performed as a way to identify either structural design flaws or manufacturing defects, and to verify the durability of the blade to withstand long-term fatigue during the course of its twenty year lifespan. Laboratory testing simulates the estimated 100 million revolutions a turbine will undergo, which ordinarily would take several years

to complete. They achieve this by increasing loads across the turbine, allowing them to complete testing over several weeks, or merely one million revolutions. [ii]

Recent testing has shown the need for blades to be better developed and designed, and for new materials to be used. The US Department of Energy released its own findings recently, which look optimistically at the future of wind power: "New composite materials are currently being developed that will increase the lifespan of a turbine blade, improve the manufacturing process, and contribute to the overall efficiency of turbine systems."[iii]

Energy giant Siemens has already produced its own line of blade technology, which it claims will successfully solve some of the problems posed by current design flaws. Its aerodynamic models, called DinoTail, DinoShell, and Vortex Generator, are made to reduce noise emissions, speed production, and make wind power a more reliable energy source moving forward.[iv] Siemens is also working to address another major downfall of wind turbines: inclement weather.

Responding to Wind Turbine Blade Problems Related to Weather

One of the largest detriments to blade design is the fact that with turbines stretching nearly two-hundred meters high, they are easy targets for lightning damage. In fact, this has accounted for nearly 10% of wind turbine downtime, creating a significant cost for owners needing to do maintenance and repairs. By some estimates, depending on their location, the probability of a turbine being struck by lightning ranges all the way up to 60% annually.[v] As Francisco Javier Martin Fernández, a Vestas engineer and a blade specialist, explained, "Any improvement in lightning protection would be great. We're finding this is the worst problem, especially with the longer blades." As such, Vestas has recently been working on perfectively a protection system that will become widely announced in October.

Siemens is also attempting to address the lightning problem with its own protection system. "When a wind turbine suffers a lightning strike," they say, "whether onshore or offshore, our system provides the lightning with a safe path through the turbine and down into the electrical grounding. This safe path reduces the likelihood of damage to the main components."[vi]

This is where innovation is really beginning to take off as researchers try to determine the safest methods for keeping these enormous blades safe from something that is very likely to occur. Scientists in Belgrade determined that the current system for lightning protection – placing resistors on the tower itself – is not entirely effective because they don't always intercept lightning strikes, leaving main equipment in a vulnerable position. To combat this, they have proposed their own solution: "A protective system, in the form of grounded conductive wires, in close vicinity and within the area of a wind farm, with the wire tips being kept by kites at a desired height."[vii]

The height of the kites would be significantly higher than the tallest wind turbine. Therefore, when storm clouds pass overhead, they will interact first with the wires, relieving the charge from the clouds and greatly reducing the probability of a lightning strike. With this method, they will be able to take a proactive approach to prevention, stopping the lightning before it ever hits rather than trying to react when it does. Sensors in the kites will allow them to lie dormant 95% of the time, while the other 5% will be spent interacting with charged clouds.[viii]

Advances in Research and Design for Blade Technology

As energy firms and research groups continue to search for ways to make wind energy a more reliable source of energy, funding toward this area has significantly grown. This has allowed new groups to undertake the challenges posed by wind turbines. Clemson University is at the forefront of new research. Backed by a $44.5 million Wind Program grant under the American Recovery and Reinvestment Act,

the Clemson University Drivetrain Testing Facility has been developed as a way to boost innovation in the manufacture of wind turbine drivetrains. They believe that by offering scientists and inventors better facilities to conduct their research, they will speed up the process of developing the necessary answers to the problems facing wind energy.[ix]

The laboratory is located in a converted Navy warehouse and tests all machinery that converts wind energy into electricity. Their engineers perform accelerated testing on every piece of equipment, allowing them to simulate twenty years' worth of drivetrain wear and tear in only a few months.

GL Renewables has also emerged as a group that is attempting to speed up the process toward making wind turbines more reliable and wind energy a reasonable source of electric power moving forward. Their certification and inspection system tests all aspects of the wind turbine, from its parts to its blade strength to its ability to respond to inclement weather.[x]

Finally, there are inventors who are playing with the entire concept of blade design. While the overall trend is for blades to become larger, there are some who are going in the opposite direction. Small, efficient blades are easier to maintain and repair when things go wrong, and are less susceptible to weather phenomena. However, they also generate less power, which would require many more of them to be designed and placed on a wind farm. There is still ongoing debate into which design is more cost-effective.

Better Standardization for Blade Manufacture

While advances in research and design as well as testing techniques will definitely improve the performance of wind energy systems, Francisco believes that greater standardization for blade certification is also required. "Up until today, the standard for lightning protection, for instance, has the same as that for buildings. Given the height difference between the average building and these turbines, this system is not realistic. Even if you have a skyscraper, it will never receive the same number of lightning impacts as a turbine. We've seen wind farms in Greece where one turbine received 30 strikes in one month. This is because you have an electrical machine 100 metres above the ground that's creating static electricity as it spins. Essentially you're inviting lightning to the wedding."

Francisco went on to explain that currently there's one standard for certification, but that the conditions in which these turbines are installed are extremely varied. Today, the same standard applies to turbines installed in Australia, Colombia, Spain, and Northern Germany.

"How can one standard apply to the changing conditions in all of these areas?" In particular, blades face a multitude of weather impacts depending on their location. Some may face sun damage while others dust damage. In other areas, fungus or salt may be a problem.

Further, he suggested that customers need standards for how to maintain the blades as well depending on climate and weather. This alone could greatly reduce the maintenance and operation costs.

Looking Ahead in Wind Turbine Blade Design

As wind energy continues to gain a foothold in the overall energy picture, there is an increased demand for high-level research and development as well as greater standardization and certification. Some, like Saphon Energy, are looking beyond blade design altogether. They have developed a zero-blade technology, which they claim will revolutionize the industry. According to their findings, "by replacing the turbines' blades with a sail-shaped body with high aerodynamic drag, our device is capable of capturing twice as much kinetic wind energy as conventional bladed wind turbines for the same swept area." The design is also supposed to reduce aerodynamic losses by, as Saphon describes, "swallowing a great part of the blowing wind." [xi]Independent research has yet to support the strong claims made by Saphon Energy.

But most continue to focus on optimizing testing and design in order to ensure a higher level of performance and reliability. Many universities internationally have already opened research labs and facilities, and some are offering certification and degree programs to students wanting to study this emerging energy source. This bodes well for the industry as a whole, as innovative design is needed to make wind power more affordable and reliable before it becomes a major energy source in the world.

Maryruth Belsey Priebe

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.

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