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Bigger, Smarter Rotor Blades for More Wind Energy

Despite the fact that wind power capacity has been expanding globally over the past few years, there's still tremendous pressure on the industry as a whole to continue to innovate in order to compete not only with conventional energies like oil and gas, but also to be competitive with other renewables like solar. As such, wind turbine rotor blade designers are looking at a variety of factors to improve the energy output and cost effectiveness of these massive machines. They're improving mechanical and aerodynamic performance, while also looking to improve durability and weatherability in order to realize operation with less damage due to environmental conditions. Of course, in everything they do, rotor blade makers must think about reducing costs, not only during manufacture, but also for transportation, installation, and maintenance. It's a tall order, but one which the industry is racing to meet. Because of each of these areas of focus, the industry is in the middle of a massive development frenzy, with many creative and unique solutions coming online now and in the near future.

The Race to Make the World's Biggest, Longest Blades for More Wind Production

Today, increasing blade size is still the means most commonly used to create a larger swept area in order to boost the amount of energy that can be captured. Blade designers are in a race to increase their rotor's capacity factor – the measure of how much time a turbine spends in service under variable wind speeds. After all, if the turbine isn't moving, it's not making money. By and large, most sites experience a lot of wind variability, with plenty of sites that have an abundance of low- to medium-speed winds, making turbine downtime a real problem. The need to develop wind turbines that are functional 24/7 is directly tied to ensuring wind competitive with fossil fuels, hydro, and nuclear – conventional energies that can put out power all day and night, on demand.

While there is virtually no limit to the potential increase in captured energy (or capacity factor) by increasing blade size, there is a significant challenge with cost and speed of production as blades get larger. Manufacturing challenges, transportation issues, and volume (and materials supply) problems all plague the industry as they push for ever larger rotor blades to reach for the hoped-for 10 MW and 20 MW turbines for offshore installations.

Perhaps the most notorious of big blades are the B75 mega blades from Siemens, which are being trialed at a test station in Denmark. With a total span of 500 ft (154 m) and a swept area of 200,200 ft2 (18.600 m2), the blades are made with the company's QuantumBlade design that's 20% lighter than

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conventional blades, and are molded using their IntegralBlade process (fusing the entire blade together in one closed mold) using materials such as epoxy resin, glass, and a balsa core. Able to withstand wind loads of 200 metric tonnes, these blades have been installed at the Gunfleet Sands III wind farm in the UK, with more scheduled for installation by DONG Energy in the UK.[i]

Research into these kinds of mammoth blades is being conducted all over the world, with the tech incubator Sandia National Laboratories' Analytical Structural Dynamics department another example. Their 13.2 MW, 325 ft (100 m) is being tested using an all glass baseline to determine aerodynamic performance and determine how to reduce mass. So far, the research shows that the massive blade performs within international design standards for material and load and is working as anticipated din terms of spanwise strain and tip deflections.[ii] Once they've worked out the design specifics, a lighter blade will be developed and tested.

Speaking of big blades, one of the largest around is that of LM Wind Power. Their 240 ft (73.5 m) all-glass blade has been developed in partnership with Alstom for their Haliade 150 6 MW offshore turbine. The turbine is said to produce enough power for 5,000 homes using a gearless direct-drive design in order to protect the blades from the bending stress by diverting it into the tower. Alsom has recently begun building the manufacturing facilities to produce these blades in France and hopes to pump out 100 sets every year by 2016.[iii]

Smarter Manufacturing for Better Energy Capacity, Lower Costs, and Longer Wear

But length isn't the only way to boost production and reap a larger return on investment. Another method being used by many blade manufacturers is to play with materials, optimized designs, and better, faster, more efficient manufacturing methods in order to drive down the costs of rotor blades. After all, there is a law of diminishing returns with relation to building ever bigger rotor blades – as you increase the size, you also increase weight and turbine load, which diminishes how much of energy increase you can achieve with the length increase.

For manufacturers, using smarter manufacturing means many of things. Some are turning to ultra lightweight materials including composites made of glass, wood, polyester, and/or epoxy. Others are tweaking the blade profile in order to increase length without increasing the root diameter. As blades get longer, many manufacturers are moving in particular away from E-glass production to carbon fibers which are lightweight. Though they're more expensive up front, they make a lot of sense for offshore applications where their stiffer, lighter features help them capture more energy.

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Carbon fiber is commonly used today in onshore and offshore applications for the structural spar of a wind blade (especially those over 148 ft or 45 m in length) in order to increase stiffness while lowering density to create a thinner profile. It is estimated that by transitioning from glass to carbon fiber in this way, a 20% reduction in weight can be achieved per blade. [iv] When these weight reductions are seen in all three blades, it can result in a substantial weight reduction overall in terms of turbine and tower size and weight.

Gamesa and Vestas have specifically been using carbon fiber for structural blade parts while reducing the heft of tower and turbine, too. The knock-on cost benefits of carbon fiber over glass fiber have been highly advantageous for the two firms. For Vestas, for instance, their carbon fiber design allowed them to add 16 ft (5 m) to their low- to medium-wind blade without weight gain. With the same weight as their 144 ft (44 m) blades, these 179 ft (54.6 m) blades have a 55% larger swept area.[v]

Rumors are also swirling about a game-changing new blade design that uses not a polyester or epoxy resin, but rather a new kind of resin that is rubbery, allowing for the manufacture of large segments without blade buckling risks. [vi]

Materials are also the key to achieving longer life capacity for rotor blades. These blades must withstand the wear of ice, sand, salt, rain, and of course wind. One of the greatest concerns for blade designers is leading edge erosion which has the potential to greatly reduce power output and vastly reduce revenue from a wind farm. By some estimates, environmental erosion on the leading edge can, over time, cause pitting, delamination, and gouging to such an extent that it can reduce a turbine's annual energy output by up to 20%.[vii]

New coatings are being developed by a variety of blade manufacturers, including Arkema Inc. (Prussia, PA). Their KYNAR PVDF coating is an acrylic hybrid emulsion which has previously been utilized for architectural weather protection on exposed metal. Though original versions of the material, which have been in use for more than 30 years, required baking at high temperatures, the company has created a method of curing using a water based solution that can be applied at room temperature with both thermoset formulations and thermoplastic formulations. [viii]

LM Wind Power has also created their own proprietary blade coating. They recently introduced ProBlade Collision Barrier, a coating that is said to improve erosion resistance along the leading edge up to 20 times compared to standard barrier coatings. Made of aliphatic-based, solvent-free polyurethane topcoat that is highly elastic and a primer, the coating has been independently tested, demonstrating that it lasts up to twice as long as thermoplastic polyurethane tape leading edge protection, a protective coating that usually results in aerodynamic drag. ProBlade coating is already in production.[ix]

Another approach to leading edge protection is protective tapes that are intended to cut erosion, tearing, punctures, and weathering using helicopter blade protection technology. These tapes are made using polyurethane elastomers that are abrasion resistant and tough, protecting a blade from erosion and water ingress. They can be installed on complex shapes in the field or on the factory floor without any special application tools. Because they can also be applied to existing blades, this type of protective tape can provide extra erosion resistance without the downtime that would be required to transport blades off the field for re-coating.[x]

Industry Recognizes the Importance of Advanced Rotor Blade Designs for Success of Wind Energy

Clearly the wind industry is paying attention to the possible benefits better blade technologies will have for the industry as a whole. Whether it's a longer blade or better coatings, rotor blades that perform better and at lower costs will help to keep wind in the running as a competitive energy source.

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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

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