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Is Blade Segmentation Risky Business for Wind Energy?

The market for wind turbine rotor blades is on the rise, with key countries like Spain, Germany, the UK, China, India, the US, and Canada all looking to increase their wind power development over the coming years.[i] Global wind power as a whole increased its capacity by about 16%, with a total of 45 GW added during that year.[ii] But as ideal wind farm sites disappear and more challenging terrain and marine environments are explored as potential locations for new onshore and offshore developments, rotor blade manufacturers must adjust their designs to account for varying wind conditions, more remote installation locales, and difficult installations. All of these demands on the industry are pushing rotor blades to develop and mature at a rapid pace, with innovations such as blade segmentation garnering a lot of spotlight in recent years. Offering the opportunity to produce ever-longer blades at lower costs, modular blade designs come with both pluses and minuses as you'll soon see.

The Pros and Cons of Modular Rotor Blade Designs

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Across the industry, engineers are running into all manner of challenges as they push the limits of rotor blade length. One such challenge is maintaining aerodynamic accuracy and high quality when the lengths are so tremendous. The costs of tooling these large blades can also be extremely high. Further, transporting mammoth blades onshore and offshore is an extremely difficult logistical challenge and one that costs a significant amount.

To avoid these challenges, many blade designers are now looking to modular rotor designs, with many variations on the theme seen from manufacturers around the world. They're the first to tout the benefits of choosing a segmented blade design.

Lutz Beyland, Composite Design Engineer of German Aerospace Center (DLR), suggested that the biggest benefit of the segmented blade is as follows, "Peripheral sites with low wind speeds (e.g. in southern Germany) need to be served with long-bladed turbines to be competitive. Transportation of unsegmented rotor blades to those sites will be more expensive and sometimes even impossible."

Beyland isn't the only one praising blade segmentation for the flexibility it offers for transport. Smaller components, obviously, are much simpler to transport from one location to the other. This reduces the need for specialized transportation vehicles and complex logistics.

Ion Arocena, G10x Blades Chief Engineer at Gamesa Innovation & Technology, expanded on this benefit of blade segmentation by making these comments, "Blade segmentation is the key technology to install multi-megawatt wind turbines in onshore complex terrain, since standard roads do not allow transporting blades longer than 60/70m to a large number of wind farms. This facilitates a significant reduction in the cost of energy, especially for those wind farms with limited space."

Gamesa's 4.5 MW turbine is one of the company's multi-megawatt machines that they're calling the most powerful land-based platform. The first in this line is also the world's first segmented blade. The G128-4.5 MW turbine has a 128 m rotor size and 62.5 m blade which is assembled in parts. They estimate that the transport and assembly costs of this turbine are on par with a 2.0 MW turbine. They further lower the costs of installation of this modular design by installing a FlexiFit crane – it mounts to the nacelle to assemble and service the turbine. And in case there's concern that these blades will not perform as well, prototypes installed in Jaulin, Spain, achieved a 100% availability in December 2012.[iii]

Ease of transportation is perhaps the most obvious benefit of segmentation, but modular blades also could create cost savings during manufacture as well. Unsegmented blades, for instance, are most often formed using single moulds – when we're talking about 70+ meter sized blades, the moulds need to be pretty big. The costs of this kind of manufacturing method are extremely high. Segmentation could alleviate this cost challenge significantly.

Yet there are still downsides to opting for a segmented format for rotor blades, not least of which are concerns about stability. Additionally, Arocena suggests that the complexity of a turbine's design and installation can get more complicated with segmentation which has the potential to drive costs up rather than down. But Arocena suggests this is not an insurmountable problem: "Since blade modularity increases the complexity of some manufacturing and assembly activities, Gamesa portfolio includes both modular and non-modular variants for multi-megawatt onshore Wind Turbines, to adapt the product configuration to the wind farm characteristics."

Image Via Flickr: the_moni_moni

Case Studies in Segmenting Ultra-Long Wind Turbine Blades

There are many manufacturers currently tweaking their own version of the segmented rotor. Blade Dynamics, for instance, is developing a segmented blade that includes a carbon/epoxy box spar. Though many details about the finished design have yet to be released, we do know that the profile will change along the length of the blade and that there will be no mechanical fasteners required to assemble the blades in order to avoid stress risers. The blades will use a bonded approach, though length and fabrication methods have yet to be announced.

What makes their design so interesting to the industry is the fact that the individual segments should fit into standard shipping containers. In other words, they will not require specialized vehicles for transport, which should vastly reduce this budget line for moving them from manufacturing facility to installation site. Further, because the Blade Dynamics' design requires multiple skin panels that are attached along the length of the blade using a variety of materials, the company says it will be looking to outsource production of these segments to composites molders in close proximity to any given wind farm site. Obviously this will make local assembly that much easier, faster, and cost-effective, while offering tremendous cost benefits for deployment and installation.

Energy Technologies, a UK-based firm, recently provided £15.5 million ($23.6 million) in funding for the production of Blade Dynamics' approach, with the aim of producing a 8 MW to 10 MW offshore demonstration turbine of 100 m or 325 ft in length. Production of these blades is anticipated to begin in late 2014.[iv]

Another modular approach is that of Wind Power Future which creates metal inserts that are built into the carbon fiber blade during manufacture. Bolting the insert to the hub, this insert allows for a slimmer, stronger, more aerodynamic blade. The carbon fiber segments can then be manufactured in modules allowing for greater material consistency and reducing failure risks.[v]

One extremely large blade is being developed by SSP and Samsung Heavy Industries in Seoul, South Korea for their upcoming 7 MW offshore turbine project near Jeju Island in South Korea. Fabricating the root and spar separately and then assembling the components in a resin infusion process, the blades are 271 ft or 83.5 m in length. Making the blades requires the use of the company's honeycomb core, glass-epoxy prepreg molds which are relatively lightweight and much more maneuverable than conventional metal molds. The unique design can actually be shipped in two halves to the installation site, assembled on site, thereby reducing transport costs drastically.[vi]

In yet another take on the idea of blade segmentation is Envision's segmented blades are created in such a way as to achieve a partial pitch when in operation. Like other manufacturers, Envision is tapping into the cost benefits of transporting and installing smaller segments by going with this design. But their added optimization partial pitch capability could create big energy boosts, too.

These blades are built with a fixed blade angle – the extender – that is installed on the inner section of the blade. Attached to this extender is the pitchable outer blade. Using pitch bearings and an electric pitch control mechanism installed between the two blade segments, the glass-fiber-reinforced composite blade reduces extreme loads by 30%. Estimates indicate that this design could result in a 10% overall turbine cost reduction, especially when it comes to tower and foundation manufacture and installation.[vii] More testing is being done before production begins.

Are Segmentation's Benefits Enough to Outweigh Increased Big Blade Manufacturing Costs?

Certainly there are some substantial benefits to the segmentation of rotor blades for the wind industry, but there are also concerns about how this will play out in the coming years in terms of blade complexity and stability. As Beyland points out, "Cost of production and materials of segmented blades will increase." In fact, Beyland goes on to ask an important question, "Will the savings in transportation be enough to compensate these additional costs?"

Time will tell.

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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