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Energy Innovation is Blowing in the Wind

University of Dayton, Ohio (url: http://www.udayton.edu/index.php)

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If the answer to energy innovation is blowin' in the wind, Ohio is the place to capture it. So say engineers at the University of Dayton Research Institute and their partners in a number of wind-energy programs funded by state, federal and private sources.

The Research Institute received $270,000 in Ohio Third Frontier funds for research to design and test structures and materials for composite wind-turbine towers – fiberglass reinforced resin monoliths that will stand as much as 65 feet taller than the steel towers currently dotting wind farms around the world.

"The U.S. Department of Energy has reported that by 2030, 20 percent of all electricity generated in the U.S. could be supplied by wind. But a number of design and material advancements need to be made in wind-turbine technology before that can happen," said Brian Rice, University of Dayton Research Institute division head for multi-scale composites and polymers.

Wind turbine towers need to be strong enough to carry the weight of the turbine – as much as 100 tons – and resist buckling under the stress of the rotating machinery, Rice said. To accommodate weight and stress, steel monopoles are pre-fabricated in sections as large as 14 feet in diameter and 70 feet long, then trucked individually to the wind site to be fit together and installed on a concrete foundation. In finished form, the average utility-grade tower height is about 80 meters, roughly 265 feet.

But the wind industry has been setting its sights on a new standard for tower height at 100 meters (328 feet), Rice said. Putting larger turbines atop taller towers facilitates access to greater wind speeds, which improves operating performance and cost. As the size of wind turbines continues to grow, however, so grow the problems and expense associated with transporting and building the towers.

"If you increase the height of the tower, you have to increase its diameter as well," Rice said. "Which means that next-generation wind turbines will require towers that will be too large to ship via highway, even in sections."

The solution, Rice said, is in composites – fiberglass and resin tower sections that would be manufactured at the wind farm using raw materials trucked to the site. The manufacturing operation would be staffed primarily by local labor.

"On-site fabrication eliminates the transportation problems and makes more sites accessible to wind power development," Rice said. "Even today there are good potential wind farm sites in remote or hilly locations, but there aren't sufficient roads to allow for trucking in steel towers; the new design would solve that problem as well." In addition, the corrosion-resistant properties of composites will be far more suited than steel for off-shore wind farms, which are just starting to be developed in U.S. waters, he added.

The Ohio program team, comprising lead partner Ershigs Inc. in Manchester, the University of Dayton Research Institute and Edison Materials Technology Center in Dayton, WebCore Technologies in Miamisburg, Owens Corning in Columbus, and Ashland Performance Materials in Dublin, has been working for more than two years to test materials. The team is now prepared to move into product demonstration, Rice said. The partners will design, analyze, build and test a series of progressively larger components with a goal of completing and testing a full-scale 100-meter composite tower.

"In full size, these will be some of the largest composite structures ever built," he said.

In a complementary program, University of Dayton researchers are working on an Air Force advanced-materials contract to develop smaller composite wind turbines to generate electricity in areas of low-speed wind. The smaller turbines, which can be trucked in sections and erected in remote military installations, will also serve well in civilian settings where wind is low and energy demand not great, such as rural areas and industrial parks in Ohio.

While researchers in Rice's division are working on tower components and materials, researchers in the Institute's aerospace mechanics division are working with Twenty First Century Energy of Fairborn to design and produce a vertical-axis turbine for the same program. The blades of vertical-axis turbines are parallel to the ground, making them look more like personal fans than airplane propellers, said Dan Bowman, University of Dayton Research Institute division head for aerospace mechanics.

"These smaller turbines will reduce the need for fuel delivered to forward deployed bases, such as those in Afghanistan and Iraq. The challenges to trucking fuel into these areas makes it expensive – as much as $100 per gallon," Bowman said. "Any electricity that can be generated by wind rather than diesel-fuel generators will represent a huge cost savings for the military."

The same holds true for the domestic market, Bowman added. "Transportable wind turbines could be set up at schools, hospitals and municipalities to reduce the amount of burned natural gas and other fossil fuels."

The $700,000 Air Force program awarded in 2009 has received $1 million in additional funds for year two, to begin in May.

Rice said UDRI's decades of experience in aerospace and materials research created a base of expertise for its jump into wind energy research.

"A wind turbine has many of the same structures and systems as aircraft, including coatings, lubricants, bearings, electrical systems, composite components and other design elements," he said. "We're leveraging our expertise in these areas to create a center of excellence in wind energy, which will support the creation of green-collar jobs in Ohio."

In January, the Research Institute received a $41,500 Small Business Innovative Research grant from the National Science Foundation to design and test sensors for wind turbines. The sensors, to be manufactured by Mound Laser and Photonics Center Inc. in Miamisburg, will monitor the structural health of turbine blades and provide warnings if parts are in need of repair or replacement.

"Sensor systems will play a critical role in helping to prevent catastrophic failure of turbines," said Mike Bouchard, University of Dayton Research Institute division head for structural integrity. Bouchard said successful demonstration of the sensors in a lab setting will pave the way for additional funding for full-scale testing in the field.

Researchers also are awaiting word on an Ohio Third Frontier Sensors Program proposal that, if awarded, would provide funds for research and development of systems and devices for "intelligent wind farms." Research led by International Health Monitoring Systems of Dayton in collaboration with the Research Institute, the University's? Ladar and Optical Communication Institute and other partners, would include automated structural health monitoring, lidar (light detection and ranging) wind and turbine monitoring, and smart learning controls for improved wind turbine efficiency.

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