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Cranes and Wind Power: A Critical Pairing

From the day a turbine is erected, to the time it is ready to be taken down, cranes are necessary tools for building and maintaining wind farms.

By Kate Nation

Wind energy continues to be a robust industry with wind-farm construction predicted well into 2020. The U.S. Department of Energy's Wind Vision Report states the U.S. may be able to meet 10 percent of its electricity needs through wind power by 2020 and predicts meeting 20 percent by 2030 and 35 percent by 2050.

Since turbines cannot be erected or maintained without cranes, the numbers coming from the wind industry bode well for companies that offer crane and heavy-haul services. Construction companies with in-house fleets are well-positioned to handle current market needs, but the predicted growth will require planning.

Wanzek Construction, Inc., a heavy industrial contractor specializing in wind-energy construction and O&M services, sees its in-house fleet that includes 40 cranes as a key business asset. Looking beyond 2016, Bryce Peterson, vice president of Construction over Wanzek's crane services division, is developing an approach that will lay the foundation for a quick-response crane supply program.

SUSTAINABLE GROWTH

"Wanzek has implemented an advancement plan structured to allow for sustainable growth," Peterson said. "The crane services division is applying the same plan on a micro level to our department."

The program includes a focus on communication and planning, including a newly rolled out Mobile Vision Program (MVP), specialized training, a lean Kaizen approach to quality, and a continued commitment to safety.

Since crane equipment is essential to wind projects throughout the life of a wind farm, including maintenance and end-of-life, access to cranes may become a critical issue to wind-farm owners and operators for both construction and operations and maintenance.

Wanzek has established relationships with crane suppliers as well as large rental vendors. Part of that planning is balancing owned assets and rental assets to keep ahead of supply. The company has entered into several long-term lease agreements to ensure clients' future needs for both construction and maintenance are met.

CRANE SERVICES VITAL

Jake Nikle, division manager of Wanzek's O&M Services, said crane services are vital to all phases of a wind project.

"From the day the turbine is erected, to the time it is ready to be taken down, cranes are a necessary tool for building and maintaining wind farms," he said. "Following construction, most sites will have the need for 350-600t cranes a couple times per year to replace major components such as gearboxes, main bearings, generators, and blades. Advances in technology have improved turbine component design in recent years, which may make it more cost effective for cranes to replace certain components site-wide, extending the life of a site by 10 years or more. And when a PPA comes to an end or the turbines no longer operate efficiently, the wind project may need to be decommissioned. The safest way to remove the turbines is using cranes in

a reverse of the construction phase of the project."

Wanzek's O&M services team performs rotor replacement with an all-terrain crane. (Courtesy: Wanzek)

MOBILE TECHNOLOGY INITIATIVE

Wanzek's mobile technology initiative, MVP, is part of its communication plan. It expands the use of mobile devices in the field and establishes daily integration of information with the company's back-end systems. This allows field and corporate management teams access to real-time information. These "smart job sites" have proven critical to establishing an uninterrupted communication channel.

MVP gives crews access to reports, inspections, and manuals at their fingertips. It also allows teams to determine — in real time — any potential

ALSO IN THIS SECTION

Wanzek's O&M services team moves a fully assembled 600T all terrain crane between towers. (Courtesy: Wanzek)

maintenance issues that could lead to downtime, plan scheduled maintenance items such as oil changes, and quickly verify equipment maintenance status between projects to ensure machines are always in prime condition for the customer.

Peterson sites communication as a major factor in successful turbine maintenance.

"Mobilization is one of the main costs associated with large crane usage on-site," he said. "If you are working with owners to forecast possible future repairs, you have the ability to reduce the number of times a crane needs to be mobilized to the site by handling multiple projects on the same trip, reducing the costs dramatically."

Nikle agreed.

"We aim to minimize the total time our cranes are on site, which helps keep our customers' costs down," Nikle said. "Communication between the client and our team is essential. The more information we have about upcoming crane needs, the better we can schedule sequential projects in the area and reduce overall costs to the clients."

Advancements in wind technology have led to an increase in turbine sizes. According to The American Society of Mechanical Engineers (ASME), rotors have increased in size from about 150 feet in diameter to 400 feet in diameter with towers more than 300 feet high. These size increases allow turbines to extract more power from the wind.

USING LARGEST CRANES

The increase in size also means turbine erection requires some of the largest cranes in use today. Crews are lifting components in excess of 90 tons to 300-plus feet. Wanzek's safety and training includes hazard analysis, crane assembly/disassembly, inspection, wind/weather consideration, travel paths/limits, control of lift area, and lift planning. Wanzek's O&M Services team also has personnel certified to Global Wind Organization (GWO) standards for tower rescue, fire prevention, material handling, and emergency response.

In order to retain high quality standards during peak market demand, Wanzek's crane services team plans to implement the company's lean Kaizen approach. This method focuses on incremental changes in processes to improve efficiency and quality. Since most wind-farm sites are remote, the team has performed a lean quality initiative on crane set-up and tear-down in order to reduce time spent during mobilization and transport from site to site.

"Lean quality initiatives have been a great asset to Wanzek's crane services," Nikle said. "Our teams have used a variety of tactics from 5S for organizing tools and rigging to spaghetti diagrams and value-stream mapping to improve jobsite layouts and crane assembly times."

In addition to using a lean approach, the company highlights best practices.

"All of our operators and riggers are certified and knowledgeable of the equipment they work with and around," Nikle said. "Proper maintenance is key to keeping equipment in top operating condition. It's essential that cranes are operated within their rated capabilities and manufacturer specifications. Wanzek crane and rigging engineers design our lifts using additional factors of safety to ensure safe operation."

GOOD SIGN

The extension of the wind energy Production Tax Credit (PTC) and Investment Tax Credit (ITC) is a good sign that construction will continue on wind-energy projects. The Environmental and Energy Study Institute (EESI) suggests the extension could result in the installation of almost twice as much wind capacity in the U.S. as would otherwise have been the case between 2016 and 2020.

According to the EESI, more businesses are securing their own clean energy sources. Business procurement of clean energy doubled in 2014 and again in 2015, reaching 3.5 GW. Wind energy has attracted the most corporate investment.

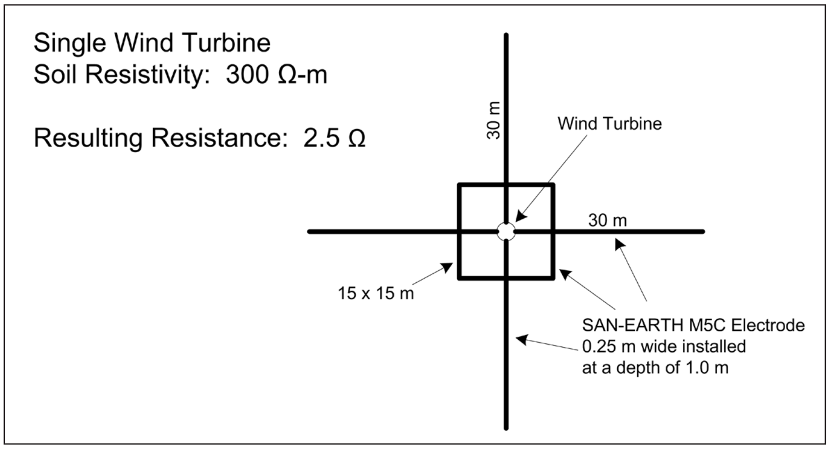
With wind project construction booming and end-of-life efforts beginning for first generation wind-farm equipment, crane and heavy-haul transport will continue to be a significant aspect in the success of wind-energy growth. Equipped with an extensive in-house fleet, long-term, second-party leases, and a multi-tiered growth plan, Wanzek is positioned to meet the expected high demand for efficient crane services for the wind industry.

Kate Nation holds a B.A. in English from the University of Georgia and a B.F.A. in art and design from Winthrop University. She is an in-house writer and graphic designer for Wanzek Construction, Inc.

Grounding: The Key to Lightning Protection

Sankosha develops conductive grounding cement to decrease turbines' vulnerability to storms.

By Bruce Thatcher



By their very nature, wind turbines end up in harsh locations where damage from volatile weather makes them vulnerable.

In fact, wind turbines may be the most exposed of all types of generators connected to electric-power networks. Costly lightning-related damage is most often caused by insufficient direct strike protection, inappropriate or inadequate transient voltage surge suppressors, or unsatisfactory bonding and/or grounding. Lightning damage results in expensive repair or equipment-replacement costs, and it is the leading cause of unplanned wind-turbine downtime resulting in the loss of countless megawatts of power generation. It has been reported that up to 80 percent of paid insurance claims for wind-turbine damage were caused by lightning.

A REAL THREAT

As tall, isolated towers composed of sensitive electronics, wind turbines face a persistent and real threat from lightning. Advances in wind-turbine technology have made them both more sophisticated and more vulnerable, but a properly designed lightning protection system will prevent physical damage to the turbine by redirecting lightning currents to Earth.

The cost of these lightning-protection systems represents a small portion of the total project capital expense but results in a dramatic improvement in reliability.

LIGHTNING-VULNERABLE SYSTEMS

The following systems, arranged in order from most-to-least vulnerable, may be damaged by lightning. The National Fire Protection Association handbook explains that physical blade damage is the most expensive and disruptive damage caused by lightning, but damage to the control system is the most common.

- Control Systems: Sensors, actuators, and steering motors.
- Electronics: Transformer station, frequency converter, switchgear elements, etc.
- Blades: Dramatic temperature rise to as high as 30,000 degrees C, causing delamination, surface damage, melted glue, and cracking on the leading and trailing edges. (Much of the damage may go undetected while significantly shortening the blade's service life.)
- Generators.
- Batteries: May be destroyed or even explode.

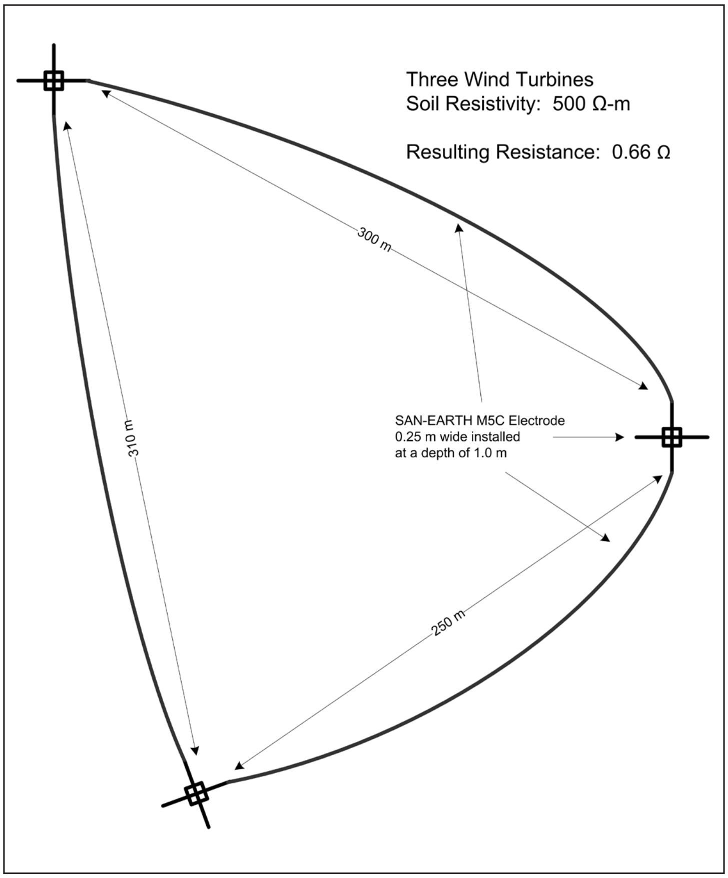
Lightning-stroke density in the United States during the 10-year period from 2005 to 2014 ranged from a low of less than one stroke per square kilometer per year in the far West to more than 32 strokes per square kilometer per year in some areas of the deep South and Florida, according to the Vaisala National Lightning Detection Network.

In its early years in the U.S., the wind-farm industry was concentrated in the low lightning-frequency areas in California, but, as it expanded to other regions, lightning exposure increased dramatically.

An integrated lightning-protection system design combines several components to minimize risk. Wind-turbine blades, the nacelle, structural components, the drive train, low-voltage control systems, and high-voltage power systems all must be protected. Provisions for personnel safety must also be maintained.

One element is crucial to all wind-turbine lightning protection systems: a low resistance path to Earth. The best Surge Protection Devices (SPDs) available will fail to offer protection if grounding resistance is high.

Designing an effective grounding system for single turbines or entire wind farms in high resistivity environments poses a serious challenge.



SOLUTION TO PROBLEM

San-Earth conductive cement offers a safe, economical long-term solution to the wind-farm grounding problem. It was specifically developed for locations where resistivity is high and access may be difficult. The recommended design for a conductive cement electrode system for a single wind turbine is shown in Figure 1. It consists of a perimeter ground totaling 60 meters (197 feet) in length combined with four radial electrodes 30 meters (98 feet) each in length and yields a resistance value of 2.5 ohms in 300 ohm-meter soil. The conductive cement electrodes are 0.25 meters (10 inches) wide and installed at a depth of 1 meter (39 inches).

In the higher resistivity environments often associated with wind-farm installations, similar low-resistance values can be achieved by simply increasing the length of the radials. Four 75-meter (246 foot) radials yield a resistance of 2.4 ohms in a 500 ohm-meter resistivity environment.

Installation is easy. First, 0.25-meter (10-inch) wide trenches are dug to an appropriate depth, 1 meter in the example in Figure 1. The product can be installed as a dry powder or mixed with water and applied as a mortar. A counterpoise wire is placed in the trench, so the material surrounds it. Over time, the cement hardens to become a conductive solid. Thus, the surface area of the grounding electrode is greatly increased, and lower resistance values are achieved. Corrosion in the counterpoise wire is prevented and conductor theft becomes much more difficult.

CONNECTING TURBINES

Wind turbines grounded in this way can be connected together to achieve even more dramatic results. In Figure 2, the grounding electrode systems for three turbines are connected together using the San-Earth design. Vertical ground rods, often difficult to install at wind-farm locations, are not needed to achieve a consistent low-resistance connection to Earth.

Grounding resistance and soil resistivity are, by definition, proportional. The system in Figure 2 would yield a resistance value of 1.32 ohms in a 1,000 ohm-meter resistivity environment. Even if the resistivity went as high as 3,000 ohm-meters, this design would produce a resistance value below 4 ohms.

Wind-turbine grounding systems must be designed, so excessive overvoltages are prevented and potential gradients that could cause damage to equipment or threaten human life are eliminated. With San-Earth, that goal can be achieved easily and economically.

San-Earth is manufactured in the U.S. and is ideal for use in areas where soil resistivity is high. It reduces construction costs and produces long-term consistent results. It is environmentally safe and conforms to IEC Standard 62561-7.

Bruce Thatcher is president of Sankosha U.S.A. Inc. He joined the company in 1988 to help establish Sankosha Corporation of Japan's first office in North America. Founded in 1930, Sankosha is a world leader in comprehensive lightning protection strategies. Thatcher's more than 25 years with the company have covered surge suppression components, lighting detection networks, and grounding systems. Thatcher graduated from The College of Wooster in 1971 and spent six years working in Japan. He returned to the U.S. in 1978 and settled in the Los Angeles area. He received his MBA from California State University in 1983.

Extreme Blade Transport

As wind-turbine blades get larger, the challenges of getting them to their final destination increase.

By Mihir Patel

A drone captures a blade trailer negotiating a turn. This highlights the "tip swing" and difficulty turning on the typical rural roads near the final project site. (Courtesy: Logisticus Project Group, LLC)

The growth of the wind industry in the last decade has brought with it a push for higher efficiency wind turbines and the ability to bring wind power to geographical areas once thought unsuitable for wind-farm installations.

With the challenges and costs associated with transmission of wind power over long distances, the industry has shifted toward the use of larger, more efficient wind turbines with longer blades. The average rotor diameter has increased from 75 meters in 2005 to 102 meters in 2015, according to the American Wind Energy Association. The taller the hub height and the larger the rotor diameter, the larger the sweep area, which makes these "supersized" turbines more efficient and also suitable for installation in lower-speed wind markets.

Many manufacturers are now producing blades up to 57 to 62 meters long, but this increase in blade length has created some unique challenges for manufacturers and developers when it comes to transporting them from their point of origin to the final project site. The options for transporting these larger blades are often limited and come with more risk, time, and cost.

A full route survey and analysis should be performed to identify transport and route options, permit requirements, and the risks associated with each mode.

OVER-THE-ROAD TRANSPORT

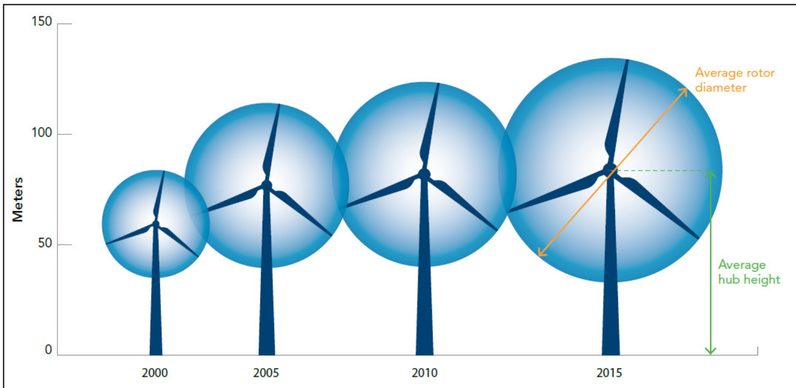
Specialized stretch blade trailers are required to haul any wind-turbine blade, but there is a limited number of trailers available long enough to transport 57-plus-meter blades. Most blade trailers were originally purchased and designed for double transport of 40-meter blades, which was the industry standard until 2011.

Manufacturers are actively creating new trailer designs, but most have not seen a great deal of blade trailer orders in the past few years. Some trailer companies have performed custom modifications to their fleet to meet wind manufacturer demands, which includes relocation of the tip fixture to the rear pullout with reinforced beams.

Beam inserts can also be added to existing trailers to extend the overall trailer length in 15-, 20-, and 25-foot increments. However, once the beam inserts are in place, they cannot be collapsed into a "legal load" and must be permitted even when moving empty. Not all specialized blade trailers have beam-insert capability, which further reduces the number of available trailers. This option is good; however, the increased permit requirement plays a large role in asset management and rotation time of this specialized equipment.

The largest available trailers can stretch to about 180-plus feet without modifications and are capable of transporting blades up to roughly 62 meters in length. However, this size trailer is used less often because of the transport and permitting challenges associated with their length. The more commonly used non-modified trailers, in the 155-foot range, can move wind blades up to 56 meters due to the federal law allowing for up to 30 feet of rear overhang. There is limited enforcement of this regulation in many states, but issues may arise as the volume increases. Some states will increase the maximum rear overhang on limited routes, but many will flag the loads and request additional verification.

And the rear overhang regulations are only the first hurdle. Permits will take longer and be more difficult to obtain, and loads will require additional police escorts, adding to the transit time and cost. Increased rear overhang also means a higher risk due to the larger turning radius and tip swing. Along the route, signs and utility poles may need to be removed temporarily to prevent damage, which increases the lead-time on permit approvals and transport. With proper pre-planning and relationship development with state entities, special allowances can be created on a project-by-project basis.



Year	Average Hub Height (m)	Average Rotor Diameter (m)
2000	58	49
2005	75	75

Year	Average Hub Height (m)	Average Rotor Diameter (m)
2010	80	84
2015	82	102

Evolution of the "Average" Utility-Scale Turbine (Courtesy: AWEA)

The "last mile" to the project site is often high risk due to narrow roadways and shoulders that require modifications and improvements prior to transport, which again add to the time and cost associated with the move.

The U.S. road network also presents challenges for moving larger wind blades by trailer, since most source locations require routing through or around major city centers. Many of these blades are imported into Gulf and West Coast ports, which requires moving them out of heavily populated areas onto the U.S. network of super-load corridors. A rough average of 700 miles from origin (port or U.S. manufacturer) to project site means more potential issues with permitting, road improvements, sign removal, and clearances.

ADDITIONAL TRANSPORT OPTIONS

Depending on the point of origin — whether a port or U.S. manufacturing plant — some developers or manufacturers may be able to consider other transport mode options besides over-the-road transport, including the use of a barge.

The Mississippi River can be used to move wind blades via barge from New Orleans, extending the source location northward. The issues associated with this mode of transport include the increased time (average of three to four weeks to transport blades from New Orleans upriver to Iowa) and the elevated risk due to more touch points in the supply chain with onloading and offloading.

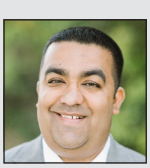
Transporting larger blades via rail is another option that can extend the source location farther inland. The use of rail has become much more common in the last year due to the challenges and costs associated with moving 57-plus-meter blades over the road.

The average rotor diameter has increased from 75 meters in 2005 to 102 meters in 2015, according to the American Wind Energy Association. (Courtesy: Logisticus Project Group, LLC)

Rail is a more cost-effective mode, especially for long distances, but it has come with its own set of challenges as the size of wind blades has increased. To minimize tip swing and potential damage to the blades, changes to the way they are loaded and attached to the rail car have been necessary. These modifications require time for design and testing, as well as the associated cost.

FUTURE OUTLOOK

The trend towards larger and more efficient wind-turbine blades will continue, requiring more creativity in both their design and transport options. Modular and jointed blades, some of which can be assembled on site, are being developed and tested by manufacturers. However, it may take years for this technology to become competitive with the conventional designs due to the issues with joint strength and stability. Until that happens, the transportation options for wind-turbine blades will have to continue to evolve to address the demands of the market.



Mihir Patel is vice president of government affairs and planning for Logisticus Projects Group, LLC. In this role, he manages a team that conducts oversized cargo transport feasibility assessments for energy companies, coordinating directly with federal, state, and local transportation entities. Patel has more than 10 years of global experience in wind-project planning and transportation-project management, having performed more than 400 route and site feasibility assessments. He holds a dual degree in Supply Chain Information Systems and Economics from Pennsylvania State University.

Offshore Wind Challenges

Digitalization becomes crucial to supply-chain logistics for North American offshore industry.

By Karen Cassidy

Large wind turbines in deep ocean waters make transportation and logistics challenging and expensive. (Courtesy: Sentient Science)

Deepwater Wind recently completed construction on its first offshore wind farm in the United States off the coast of Rhode Island. By the end of 2016, an expected 17,000 residents living on Block Island will be the first in the nation to receive power from offshore wind.

Once power from Block Island Wind Farm is commercially available, island ratepayers will see their electric bills decrease by as much as 40 percent from its current price of 50-cents/kWh to 60-cents/kWh during peak summer months, according to Deepwater Wind.

Each of the five GE Haliade 150, 6MW-rated direct drive machines about three miles off the Atlantic Coast, stand 328 feet tall and are mounted on jack-style foundations 70 feet above the water. The rotor diameter is 492 feet with blades 241 feet long and suspended 600 feet in the air.

Wind turbines this large in deep ocean waters make transportation and logistics challenging and expensive. O&M costs for offshore wind average about $40/MWh, according to the International Renewable Energy Agency.

President Barack Obama's Clean Power Plan, if approved by the Supreme Court, suggests there is potential for more than 4,000 GW of offshore development along the coastlines and Great Lakes.

As more offshore wind farms come online, it is imperative North America take its cues from Europe, who is leading the offshore wind market with more than 11 GW of installed capacity.

According to the Global Wind Energy Council's 2016 Fowind Study Report, Europe offshore wind projects use a global supply chain driven by cost and quality standards. One example of how European operators are reducing their risk is by choosing suppliers that have a track record of supplying components with a longer life.

BUY ON LIFE

A new technology that looks at the material quality for critical components has been disrupting the global onshore wind market. It simulates how the operating conditions affect the life of critical components in fielded wind turbines. Operators take the operational data from each machine, simulate the impact on life of the aftermarket component replacements, and then buy replacement parts based on the life extension it would have on the fielded turbine.

Further that, onshore wind operators use the application to monitor the current and future health of their wind assets. The service monitors each wind turbine in the fleet, providing insight into when and where rotating components begin early crack initiation that leads to failure and need to be replaced. The data forecasts future failures 18 months ahead of CBM and sensor detection, allowing the time needed to move to predictive health maintenance with multiyear budget and replacement part forecasts. This application is transferrable to offshore wind.

OFFSHORE WIND IMPACT

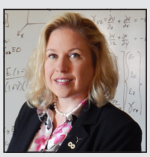
The technology would provide offshore wind operators forward visibility into how their sites are operating and what actions are recommended to keep the turbines healthy. However, when early fracture is detected, specific actions could be taken to slow down the effects of the damage and buy the time needed to purchase parts without prolonged outages.

The ability to predict failures far in advance has pronounced value for assets in such remote locations that benefit from long-term planning. Multiple turbines that have component damage in various states can then be tended to in one visit, saving on labor, crane costs, and shipping vessels.

LEARNING FROM ONSHORE

Onshore wind operators have embraced this new material science approach because it provides forward visibility into when fracturing within the subsurface of critical components begins to form. That level of visibility — 18 months to up to three years before vibration sensors — affords operators the time needed to coordinate and negotiate better terms and conditions with their suppliers and logistics companies. Further that, understanding the operational needs for each specific turbine at the individual component level helps supply-chain managers coordinate purchases, schedule planned maintenance events, significantly reduce on unplanned outages, and save on parts, labor, crane costs, and transportation from port to site.

For more information, go to sentientscience.com



Karen Cassidy is vice president of New Product Marketing at Sentient Science.