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AI-based autonomous drones can complete visual inspections for the entire turbine in as little as 15 minutes, 10 times more efficiently than traditional methods.

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Getting ready for wind business

Temperatures are slowly rising with the approach of spring, but the arrival of spring also corresponds with wind industry trade show season. There are quite a few shows on the horizon, and *Wind Systems* plans to give you the coverage you've come to expect and more this year.

On April 16-17, Wind Operations Dallas takes place, and on May 20-23, AWEA WINDPOWER 2019 is scheduled for Houston. *Wind Systems* will be making sure you get information on these shows and more as their start dates get closer.

Beginning with our March issue, we whet your trade show appetite — so to speak — with our Conversation feature.

In it, Ben Moss, projects director with New Energy Update, discusses the Wind O&M show in Dallas, Texas. The show is entering its second decade of providing hands-on feedback from key decision makers in the industry.

In addition to trade show information, this issue also offers some interesting articles focusing on turbine inspection, parts and system, and more.

An article from Clobotics talks about its efforts to advance turbine inspection by using automated drones to do a lot of the “heavy lifting.”

The Timken Company gives an in-depth look at how seven years of field testing confirmed the long-life potential of one of its wear-resistant main-shaft bearings.

And in Crosswinds, I talk with the director of energy policy and electrical markets for the Copper Development Association. In the article, she discusses how copper is a key ingredient in building the complex electrical infrastructure needed for both onshore and offshore wind development.

You'll find all this and much more in our March issue. 2019 is winding up to be another great year for wind, and *Wind Systems* will be along for the ride in order to bring you some of the best and the brightest the industry has to offer.

As always, thanks for reading!



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New legislation to help guide electrification boom

From AWEA

The American Wind Energy Association (AWEA) recently released model legislation designed to help states prepare for the consumer-driven electrification boom. The model legislation is based on findings in AWEA's new study, "A Shared Future: Electrification and Renewable Energy." The report offers insights to electricity providers, state legislators, and regulators as they develop electrification strategies, advocating for a comprehensive approach that includes electric vehicle (EV) charging infrastructure investment, renewable energy additions, and transmission expansion.

"The wind industry stands ready to help states meet their energy goals and consumer preferences in an increasingly electrified economy," said Susan Sloan, vice president of State Policy, AWEA. "Wind is already a healthy part of strong economies in places like Texas, Iowa, and California. That success story will reach even more Americans with state policies in place that support investments in renewable energy, transmission and EV charging infrastructure."

Electrification could increase electricity load growth by up to 38 percent nationwide by 2050, according to the National Renewable Energy Laboratory (NREL). Consumer-driven adoption of EVs, among other forms of transportation electrification, will account for the most significant demand increases. With more than 85 percent of the American public strongly supporting increased reliance on wind power, and EV drivers preferring to source renewable energy to charge their vehicles, wind is ideally suited to meet growing demand.

"Mass electrification across multiple sectors is a consumer-driven trend state legislators and regulators need to prepare for today," said Hannah Hunt, deputy director of Electricity Policy and Demand, AWEA. "This report offers solutions for state-level stakeholders at every stage of the electrification process, with a focus on tapping the unique potential of wind energy and investing in critical energy infrastructure."



The American Wind Energy Association (AWEA) is the premier national trade association that represents the interests of America's wind energy industry. For more information, go to www.awea.org

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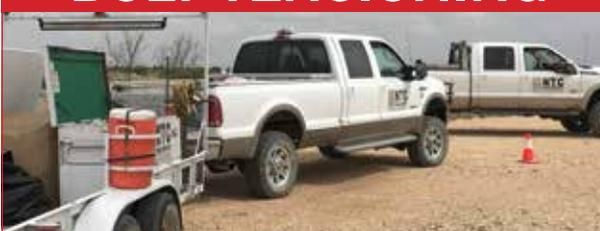
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DIRECTION

THE FUTURE OF WIND

Thanks to recent technology advancements in artificial intelligence, AI-fueled digital transformation is revolutionizing how the O&M industry operates. (Courtesy: Clobotics)

Clobotics partners with GEV Wind Power on AI-based turbine-blade inspections

Clobotics recently announced its global strategic partnership with GEV Wind Power — one of the largest wind O&M companies from Europe, to deliver AI-based autonomous blade inspections to global wind-energy leaders, thriving for full-speed digitalization of the global wind O&M market. This partnership covers all the regions that GEV is already serving, including Europe, Africa, North America, and more. Combining the deep industry expertise, top global network, and advanced AI technologies, Clobotics and GEV are taking the lead to capture the next wave of growth in this multi-billion-dollar market.

Global wind energy market continues to enjoy its double-digit growth for the last 10 years, this in turn creates a multibillion-dollar O&M market that is growing rapidly as more turbine ages. Analysts estimate that the global wind O&M market grew from \$2.12 billion in 2006 to \$13.74 billion in 2016, at a compound annual growth rate (CAGR) of 20.6 percent. The market is expected to reach \$27.4 billion by 2025, at a CAGR of 7.7 percent during the forecast period. As Navigant Research reported in 2015, cumulative global revenue for wind turbine UAV sales and inspection services is expected to reach nearly \$6 billion by 2024. Further, this did not yet account for the great potentials that autonomous UAV enabled by AI is about to unlock, nor the needs for digital asset lifecycle management. Thanks to recent technology advancements in artificial intelligence, AI-fueled digital transformation is revolutionizing how the O&M industry operates, and this perhaps will unlock a whole new part of the market that was unknown previously.

“We’ve been looking to add autonomous blade inspection to our range of product offerings but recognized that this requires enterprise-level expertise in AI technologies, which is very hard to come by,” said David Fletcher,

managing director of GEV Wind Power. “When we saw Clobotics’ solution live, we were very impressed with the technological advancement compared to the other solutions we had seen.”

“We are confident that Clobotics can deliver to GEV’s high standards of performance and safety on a global scale,” he said. “By integrating our technologies, market presence and industry expertise, the partnership between GEV and Clobotics will jointly create the most advanced wind O&M digital platform that serves clients all around the world. Naturally we are very excited about this opportunity and the tremendous value it will add to our blade maintenance solutions.”

GEV Wind Power, being one of Europe’s most experienced turbine-maintenance companies, has a significant presence around the globe. It has serviced 130 wind farms across 13 countries throughout Europe and 17 wind farms in North America, with more than 3,000 wind turbines repaired. GEV is recognized as a trusted partner by many global top turbine manufacturers such as Siemens Gamesa, GE, and Nordex. Backed by GEV’s extensive global clientele, Clobotics is going to quickly penetrate the three largest wind markets: Europe, US, and China.

“Our confidence of entering the most sophisticated wind markets comes from our strong technical backbone and continuous effort in innovation,” said George Yan, CEO of Clobotics. “We keep pushing the technical boundaries so that our industry customers can focus on what they do best, achieving the next level of productivity and growth. You can think of Clobotics’ solution as L4 autonomous driving in 3D. There is no longer dependency on highly trained human operators, which dramatically reduces the amount of labor involved and turbine down-time.”

Clobotics’ AI-based autonomous drone inspection for turbine blades has attracted a great deal of atten-

tion since it launched. Clobotics was named to the CNBC Upstart 100 List in 2018 not only because of its capability to transform the data collection process using autonomous drones, but also its ability for image recognition and data analysis muscle fueled by advanced computer vision and machine learning. In the latest BloombergNEF report on computer vision, Clobotics was also highlighted as an important computer vision solution provider for the industrial sector.

MORE INFO www.clobotics.com

Skyline Renewables acquires additional wind portfolio

Skyline Renewables has purchased a 117-MW wind portfolio from NJR Clean Energy Ventures (CEV), the clean-energy subsidiary of New Jersey Resources.

The U.S. wind farms are in Iowa, Kansas, Pennsylvania, and Wyoming providing clean renewable energy to major population centers across the country.

“We set out to become a leading North American clean independent energy platform,” said Skyline Renewables President & CEO Martin Mugica. “This latest acquisition marks an important step forward as it diversifies our portfolio geographically, and it marks the first tax equity financing fully negotiated by Skyline Renewables. We are excited to extend our partnership with Capital One as tax equity partner with this portfolio and look forward to further opportunities as we execute our strategy.”

“We are delighted to partner with Skyline Renewables to help them complete this acquisition,” said George Revock, managing director and head of Alternative Energy and Project Finance at Capital One. “This investment is emblematic of Capital One’s commit-



Skyline Renewables will grow its wind portfolio to 803 MW. (Courtesy: Skyline Renewables)

ment to be a leading supplier of financing to the renewable energy sector.”

With this latest acquisition, Skyline Renewables will grow its wind portfolio to 803 MW of controlled capacity since forming the company earlier last year as a partnership between Ardian and Transatlantic Power Holdings. Skyline Renewables announced its first acquisition of Whirlwind Energy, a 60 MW project in Northwest Texas, in March 2018. In September 2018, they acquired Hackberry Wind Farm, a 166-MW farm also in Northwest Texas, and in October 2018 announced the acquisition of Starwood Energy’s 51-percent interest in the Horse Creek and Electra wind farms, both 230-MW projects.

“We are ambitious, nimble, and we have deep industry expertise,” Mugica said. “There are many promising opportunities ahead as we expand Skyline’s reach to different parts of the country with strong clean energy assets that will allow us to actively manage our assets and optimize returns.”

CCA Capital served as advisers to Skyline Renewables to support the tax equity financing.

MORE INFO www.skylinerenewables.com

AMSOIL announces strategic agreement in China

In a public signing ceremony, global wind industry leaders Envision Energy, NGC, CLCP, and AMSOIL recently became strategic partners in the world’s largest renewable energy market.

The China Wind Energy Association and other guests gathered in Beijing to witness the wind-energy leaders signing the “Powering the World’s Renewable Future” agreement. The partnership leverages proven expertise and innovation from four sectors within the industry: lubrication from AMSOIL, smart energy technology from Envision, gearboxes from NGC, and service from CLCP. Collectively, the partnership will provide a comprehensive array of wind-industry products and services to support rapid growth in an already exploding market.

“We’re excited to join NGC, CLCP, and Envision in this strategic partnership,” said AMSOIL President and CEO Alan Amatuzio. “Our organizations share the same high standards of innovation, service, and quality, and

our combined leadership supports an ambitious vision for the future of renewable energy.”

“Being young, successful, and fast-growing are not the only reasons for our cooperation. Innovation and focus on customers are as well,” said Global Vice President of Envision Energy Kane Xu.

“It’s a great pleasure to witness this strategic cooperation among the leading wind companies from China and the U.S.,” said Qin Haiyan, secretary general of the China Wind Energy Association and vice president of the World Energy Association.

At a time of strained U.S.-China relations, the signing ceremony is a bright spot of collaboration between Wisconsin-based AMSOIL and three Chinese wind industry leaders. The strategic partnership is a perfect example of pioneering companies working together to address climate change while enhancing economic development, including meeting the goals of China’s Wind Energy Development 13th Five Year Plan and One Belt and One Road initiatives. The agreement advances global wind energy development, deepens international cooperation and will truly “Power the World’s Renewable Future.”

MORE INFO www.amsoilwind.com



AMSOIL CEO and owner Alan Amatuzio and Envision Energy Global Vice President Kane Xu. (Courtesy: AMSOIL)

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The screenshot shows a web browser window displaying the Wind Systems Community storefront for Tork Worx. The page features the Wind Systems logo, a search bar, and navigation links for jobs, events, construction, maintenance, manufacturing, services, and community. The main content area is titled "Community - Tork Worx" and includes a video player for "Tork Worx 2015". The video player shows a close-up of a hand holding a bolt. Below the video player, there is a navigation bar with links for jobs, events, construction, maintenance, manufacturing, services, community, media kit, subscribe, and contact. At the bottom, there is a copyright notice for Media Solutions Inc. and links to Facebook, Twitter, LinkedIn, and RSS.

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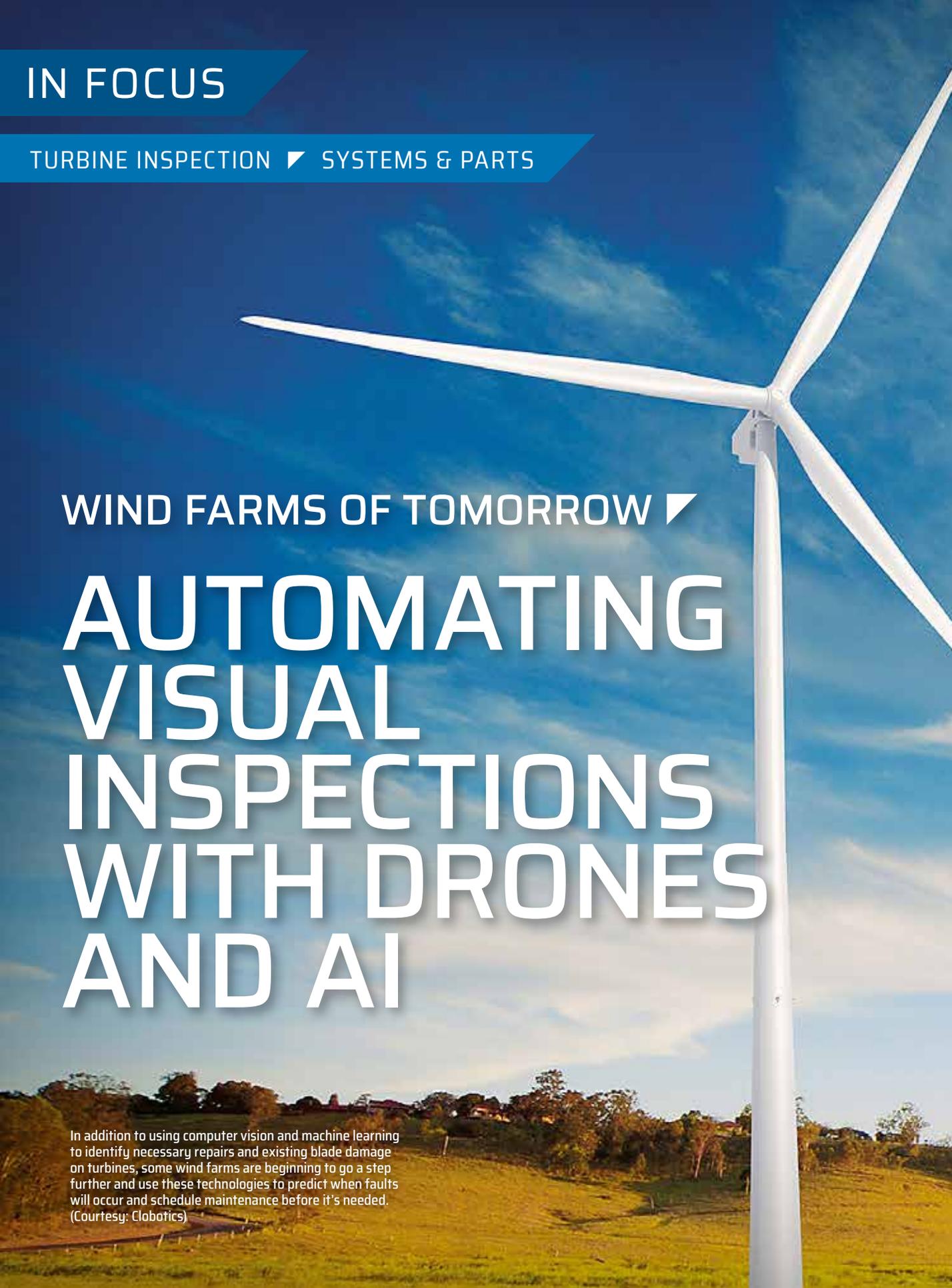


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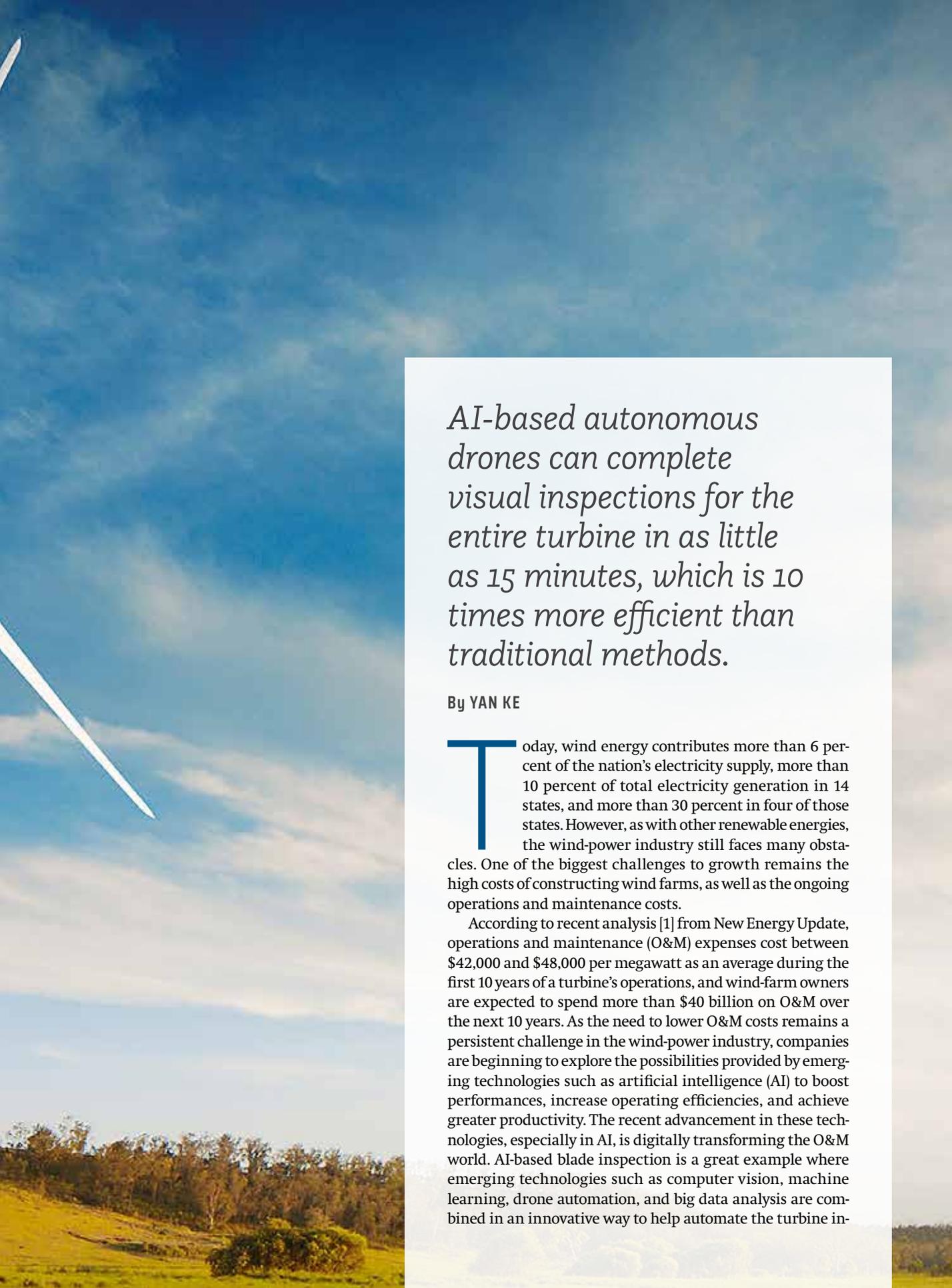
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TURBINE INSPECTION ▼ SYSTEMS & PARTS

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AUTOMATING VISUAL INSPECTIONS WITH DRONES AND AI

In addition to using computer vision and machine learning to identify necessary repairs and existing blade damage on turbines, some wind farms are beginning to go a step further and use these technologies to predict when faults will occur and schedule maintenance before it's needed. (Courtesy: Clobotics)



AI-based autonomous drones can complete visual inspections for the entire turbine in as little as 15 minutes, which is 10 times more efficient than traditional methods.

By YAN KE

Today, wind energy contributes more than 6 percent of the nation's electricity supply, more than 10 percent of total electricity generation in 14 states, and more than 30 percent in four of those states. However, as with other renewable energies, the wind-power industry still faces many obstacles. One of the biggest challenges to growth remains the high costs of constructing wind farms, as well as the ongoing operations and maintenance costs.

According to recent analysis [1] from New Energy Update, operations and maintenance (O&M) expenses cost between \$42,000 and \$48,000 per megawatt as an average during the first 10 years of a turbine's operations, and wind-farm owners are expected to spend more than \$40 billion on O&M over the next 10 years. As the need to lower O&M costs remains a persistent challenge in the wind-power industry, companies are beginning to explore the possibilities provided by emerging technologies such as artificial intelligence (AI) to boost performances, increase operating efficiencies, and achieve greater productivity. The recent advancement in these technologies, especially in AI, is digitally transforming the O&M world. AI-based blade inspection is a great example where emerging technologies such as computer vision, machine learning, drone automation, and big data analysis are combined in an innovative way to help automate the turbine in-

spection and deliver real-time data insight for wind farms to achieve greater profitability.

CHALLENGING THE STATUS QUO

Though many turbine blades today are equipped with a variety of IoT sensors measuring vibrations, sounds, and more, wind-farm operators still need greater — and earlier — visibility into the condition of blades. For instance, by the time a turbine has degraded to the point where it is vibrating or creating an unusual noise, the damage is already severe. Therefore, regular visual inspections of blades are necessary to identify cracks or other blade damage that can be fixed with a simple patch while still small.

However, traditional visual inspection approaches are labor intensive and require highly trained professionals. Traditionally, visual inspections could be carried out by either sending technicians up the tower on ropes to inspect the blades or by using ground-based scopes and cameras to capture defect photos from the base of a turbine. Wind assets have to be powered down for prolonged amounts of time, up to six to eight hours, for these types of inspections to be

depends highly on the drone operator. During an inspection, the operator needs to know exactly when and how to adjust the drone to accommodate the current wind speed and direction, so the drone doesn't accidentally crash into blades and cause severe damage. Therefore, the operator needs to be a highly trained professional. This dependency on highly-trained drone operators prevents wind farms from using manual drone inspection as frequently as they would like.

Fortunately, these are about to change by using fully autonomous drone inspections, thanks to recent advancements in artificial intelligence, especially computer vision (CV) and machine learning (ML), which made reliable autonomous inspections possible.

AUTOMATING DRONE VISUAL INSPECTIONS WITH AI

There are many forms of artificial intelligence, all of which emphasize the creation of intelligent machines that work and react like real humans. Computer vision is a technology that trains the machines to acquire, analyze, and categorize visual images or videos, mimicking the tasks that human visual systems do. Algorithms are the core of a computer vision system, and it is essential to a fully autonomous visual inspection.

What constitutes a fully autonomous inspection? Similar to the current market offerings of self-driving cars, there are various levels of autonomy for drone inspections in the market. For a fully autonomous drone inspection in the market today, it means a drone should take off on its own, locate the turbine blades, complete the inspections, and land back at the starting point.

How does computer vision help? When the drone is in the air, its on-board computer-vision algorithms help to identify the blades and determine the flight path. An optimized solution should not be a pre-programmed route,

so it doesn't limit itself to any specific make or model of turbines, turbine heights, blade-stopping positions, or location. The advanced computer vision algorithms onboard give "eyes" and "brains" to drones, so they can make the most optimal flight path decisions in the air, precisely track the blades during the entire inspection, and completely cover all the surface of every blade. Therefore, there is no longer a dependency on highly trained human operators for visual inspections, and their expertise could be saved for more high value tasks.

In addition to take-off, landing, and path finding, autonomous drones have another critical mission during each inspection: to capture high quality blade images and data. For a drone to complete an entire turbine inspection within 15



For a fully autonomous drone inspection in the market today, it means a drone should take off on its own, locate the turbine blades, complete the inspections, and land back at the starting point. (Courtesy: Clobotics)

completed. In addition to the prolonged downtime, which otherwise could be used to produce energy, images captured may not be as complete and clear as needed. Due to the height of the turbine and the shape of the blades, the angle looking up the blades is very large, and some parts of the blades are in shadows while the other parts are under bright light. This naturally makes it difficult for ground-based scopes and cameras to identify all the defects and capture high-resolution photos of them. Small defects might be overlooked, and the picture quality might not be high enough for further severity diagnosis and damage analysis.

In the past few years, drone inspections have gained a lot of attention. However, manually-operated drones have limitations, too. The effectiveness of drone inspections de-

▾ By reducing the inspection process from days to minutes with improved accuracy, wind farms no longer need to have their turbines powered-down and not generating electricity for prolonged periods of time. ▸

minutes, all pictures need to be captured while the drone is in motion — with no time to stop. This creates additional challenges for image clarity. Fortunately, advanced algorithms are used to automatically adjust the camera's settings — including focus, exposure, and white balance — so that image quality can be consistently high even when the drone is flying or when blades are under poor lighting conditions. Currently, the leading autonomous inspection system shows promising results, in that it is able to automatically identify and flag defects such as hairline cracks or chips as small as 1 mm by 3 mm. In fact, autonomous drones are so precise that they have even been known to capture and identify a common fly resting on a blade during inspection.

By reducing the inspection process from days to minutes with improved accuracy, wind farms no longer need to have their turbines powered-down and not generating electricity for prolonged periods of time. They're also able to dramatically reduce the amount of labor involved, both of which help the farms reap tremendous cost savings. Using autonomous drones for visual inspections has demonstrated enough promise such that analysts estimate [2] the market to grow at a compound annual growth rate (CAGR) of 12.93 percent during the period of 2017 to 2021 as more and more farms start adopting this technology.

BETTER PREDICTIVE MAINTENANCE WITH AI

Automated data collection is only the beginning of the benefits. By leveraging computer vision and machine learning, such autonomous drone solutions can analyze huge volumes of data in the cloud, almost instantaneously, and deliver real-time insights that can help wind farms identify trends and make decisions to improve operational performance. Recent advances in edge computing are enabling this type of real-time data analysis. Because wind farms are often in extremely remote locations, transferring data from turbine sensors to a centralized location not only takes time, but it is also limited by lack of bandwidth to these areas. With real-time data analysis at the edge, wind-farm operators can make critical decisions faster, such as shutting down a turbine to avoid cascading damage. Moreover, with cloud-based reporting, they can easily track the entire lifecycle of turbines, see the progression of damage, and view trend reports on individual turbines or their entire fleet.

In addition to using computer vision and machine learning to identify necessary repairs and existing blade damage

on turbines, some wind farms are beginning to go a step further and use these technologies to predict when faults will occur and schedule maintenance before it's needed. As mentioned earlier, the longer a wind farm waits to fix a problem, the costlier it becomes since powered-down turbines are not producing electricity. With the real-time data from visual inspections and turbine sensors, wind-farm operators can understand the growth rate of defects and determine if component failure is imminent, or if repairs can wait for a more opportune time. Predictive and preventative maintenance allows operators to save time and money by scheduling maintenance in advance, avoiding long downtimes, and scheduling repairs for times of year when weather conditions are best. ↘

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ABOUT THE AUTHOR

Yan Ke, Ph.D., is the co-founder and CTO of Clobotics, a global leader in intelligent computer vision solutions for the wind power and retail industries. Prior to co-founding Clobotics, Dr. Ke was the Chief Software Development Officer of EHang, Inc., a technological innovation company specializing in R&D, manufacturing and sales of intelligent aerial vehicles. He hired, led, and developed a group of more than 50 developers, testers, and product managers on the R&D of its drone flight control, mobile and PC apps, and server and cloud services. Dr. Ke is an expert in data mining, machine learning, computer vision, and distributed systems. He previously spent eight years at Microsoft leading the Bing Entity Understanding Group. Dr. Ke has a Bachelor's in Computer Science, a Master's in Electrical and Computer Engineering, and a Ph.D. in Computer Science, all from Carnegie Mellon University. His Ph.D. thesis topic was on using computer vision to automatically recognize human actions in videos. He is a recipient of the Intel Research Scholar Award, NSF IGERT Fellowship, Microsoft Technical Leadership Award, multiple Microsoft Gold Star Awards, published over 18 top tier conference and journal papers, and holds seven U.S. patents.

ABOUT CLOBOTICS

Clobotics is a global leader in intelligent computer vision solutions for the wind power and retail industries. Clobotics' end-to-end solutions combine computer vision, artificial intelligence/machine learning, and data analytics software with different hardware form factors, including autonomous drones, mobile applications and other Internet of Things devices to help companies automate time-intensive operational processes, increase efficiencies and boost the bottom line through the use of real-time, data-driven insights and analysis. Clobotics is recognized as CNBC Upstart 100 by CNBC and an important computer vision industrial sector provider by BloombergNEF. To learn more, visit www.clobotics.com.



SEVEN YEARS OF SOLID RESULTS

As turbine models have migrated to North America, where different wind systems create different loading conditions, manufacturers have faced new scenarios requiring new design assumptions.

Field testing confirms the long-life potential for Timken™ wear-resistant mainshaft bearings in wind turbines.

By CALEB CHOVAN

Most wind turbines are built for a 20-year lifespan, but as many owners and operators have come to find out, problems with original mainshaft bearings can arise at any time — often within the first few years. The Timken Company, as a bearing and mechanical transmission solutions leader, has been active in the North American wind-energy industry for decades, helping customers avoid costly repairs by engineering stronger bearings for the toughest conditions.

To extend the life of mainshaft spherical roller bearings specifically, Timken developed ES302, a diamond-like coating (DLC) that adds durability where adhesive wear (the rubbing together of two metal surfaces) is a common problem. Timken scientists originally developed the special nano-structure coating for low-lubrication military applications but quickly saw the tremendous potential for ES302-coated bearings in other lubrication-starved, low-speed, high-load environments such as turbine mainshafts.

Previous lab results indicated that, compared to an uncoated bearing, an ES302-coated bearing could experience up to six times greater life when operated in standard conditions and up to three times greater life under debris-contaminated conditions. Field results would have to wait, however, as the first Timken wear-resistant spherical roller bearings (with the ES302 coating applied to the ends of the rollers) were delivered to customers starting in 2011.

Finally, more than seven years later, Timken scientists were presented an opportunity to reinforce initial lab results when one 230/600-series ES302-coated bearing was removed from its turbine (due to non-bearing-related issues) and returned for analysis at the request of Timken. A close examination showed the bearing was in excellent condition and would have easily reached 15 to 20 years of reliable operation had the turbine remained in service.

Given the enormous cost of replacing hard-to-reach mainshaft bearings, it is reasonable to assume that ES302-coated spherical roller bearings could save wind-farm operators hundreds of thousands of dollars over the lifespan of a single turbine by avoiding even one, if not multiple maintenance events. Looking deeper at the problem and what Timken discovered, turbine owners are encouraged to consider the operational advantages a stronger bearing solution can bring.

ABOUT BEARING FAILURE RATES

Table 1 summarizes the considerable amount of field data Timken has obtained for standard (non-coated) spherical roller bearings used in 3-point mount turbines operating in the U.S., with each plot representing the average failure rate for a given wind farm. The data suggests that mainshaft bearing failure is likely to occur inside of 10 years and remains a major issue for wind energy producers.

Turbine Config.	Field L10 Life (years)
230 Series 3-point 2.3MW	5.5
230 Series 3-point 1.5MW	9
240 Series 3-point 1.5MW	8
230 Series 3-point 1.5MW	11
241 Series 4-point 1.8MW	~20?

Table 1: Frequent mainshaft bearing repairs have affected the productivity and profitability of U.S. wind-energy producers for years. (Courtesy: Timken)

This has left many turbine owners to wonder why mainshaft bearing failures are so common. The simple answer, in the estimation of Timken experts, is that spherical roller bearings have long been the preferred bearing choice for mainshafts due to their dominance in the European market. As turbine models have migrated to North America, where different wind systems create different loading conditions, manufacturers have faced new scenarios requiring new design assumptions. And while the market continues to adapt to these challenges, there remains a significant number of standard spherical roller bearings in mainshaft applications. Seeing the potential for an upgraded solution to extend bearing life significantly, Timken engineered its ES302 coating to withstand the typical damage modes that cause mainshaft bearings to fail.

HOW BEARING DAMAGE OCCURS

In a standard mainshaft spherical roller bearing, radial and thrust forces result in higher loads on the downwind row of the bearing, as well as a full 360-degree loaded arc of rollers. For every shaft revolution, the full-loaded arc of rollers increases the number of stress cycles occurring on each point on the inner raceway of the bearing. Given that a mainshaft typically rotates at slow speeds in the 10-20 rpm range, this does not generate significant lubricant films, even with higher viscosity lubricants. The result is higher loads, more stress cycles, and thinner lubricant film thickness on the downwind row of the bearing, which increases the risk of micropitting, especially since sliding is present.

Rollers will slide on the downwind row raceway in mainshaft spherical roller bearings due to a phenomenon called Heathcoat slip. Heathcoat slip is a geometrical constraint suffered by spherical roller bearings. As illustrated in Figure 1, if surface velocities between the inner ring and the rollers match at locations 1 and 3, then the surface velocities must differ at location 2, which means that there is sliding between the roller and the center of the raceway. Specifically, the inner raceway will have a slower velocity, making the risk of micropitting extremely high for the downwind row.

All spherical roller bearings experience Heathcoat slip, but not all spherical roller bearings exhibit micropitting. For micropitting to occur, the lubricant film thickness must be insufficient to separate the residual finishing texture, or asperities, on the roller and raceway. That is, the lambda value (the ratio of the lubricant film thickness to the composite

COMMON DAMAGE ON 3-POINT MOUNT SRB MS BEARING



Table 2: Adhesive damage is common in standard mainshaft spherical roller bearings with most of the loading occurring on the downwind side of the bearing. (Courtesy: Timken)

surface roughness) must be less than 1. Since the thickness of the lubricant film is a function of the entrainment velocity, low lambda conditions commonly occur at slow bearing rotation speeds. Therefore, the micropitting experienced by mainshaft spherical roller bearings is due to highly loaded roller/raceway sliding in low lambda conditions.

However, without highly trained tribologists (who tend to be more familiar with this type of wear) working alongside engineers in turbine design and maintenance facilities, the response by the industry oftentimes is to retrofit problematic mainshaft bearings with larger, higher fatigue load-rated bearings. For example, a common mainshaft spherical roller bearing for 1.5- to 2-MW wind turbines is the 230/600-series. In the field, it is common for these bearings to be replaced with 240/600-series bearings, which have longer rollers (spreading out the load on the raceway) and therefore have increased fatigue lives.

Naturally, the size of the bearing and the power of the turbine will also factor into the amount of bearing damage experienced. Despite this, Timken scientists have observed similar damage patterns in different turbine models over the years, given most mainshaft bearings experience high loading and repeated metal-to-metal contact. This adhesive wear can be seen in Table 2 in various non-coated spherical roller bearings (note the upwind side of the bearing will typically experience less damage).

A STRONGER COATING CAN HELP

Since the late 1990s, Timken has employed surface-engineering technologies on bearing rollers to provide wear resistance and friction reduction to demanding customer applications. Decades of research and development have resulted in new technologies that, when used in combination, expand the performance of rolling element bearings well beyond previous limits.

In 2010, in response to the problems observed in standard mainshaft spherical roller bearings, Timken proposed

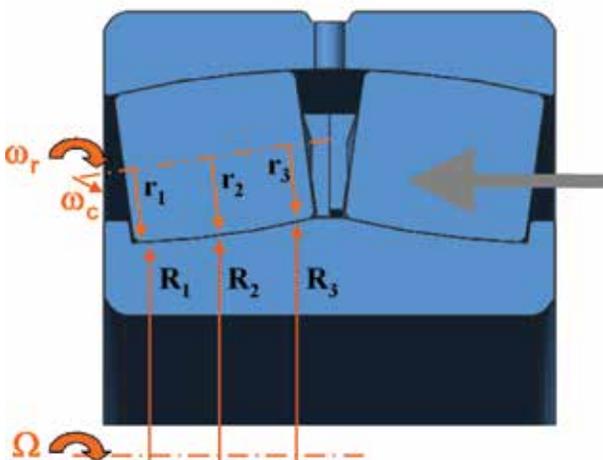


Figure 1: Physical description of the source of Heathcoat slip in a spherical roller bearing. (Courtesy: Timken)

applying a tungsten-containing-carbon-amorphous coating (ES302) to the spherical rollers of its engineered bearings. This DLC coating, effectively a crossover between a polymer and a ceramic, creates a material dissimilarity between the bearing rollers and raceway, which reduces the potential for the adhesive wear that Timken estimates to be the leading cause of mainshaft bearing failures in 3-point mount turbines.

The 230/600-series ES302-coated bearing that was returned to Timken in 2018 (the third of its kind ever produced) was originally manufactured in 2010 and installed on a 1.5-MW turbine in New Mexico in early 2011. In October of that year, the first uptower inspection was conducted, and like-new conditions were reported for the mainshaft bearing rollers and raceway. A second uptower inspection was conducted in May 2012, with only light debris damage noted. In November 2012, a third inspection confirmed the bearing remained in “good” condition. The bearing then operated continuously from 2013 to 2017 with no known issues before being removed from service last year.

Also notable is that in February 2012, a new gearbox was attached to the mainshaft and placed back into service (due to non-bearing-related issues), at which time Timken suspects some amount of contamination was introduced into the bearing cavity (likely sand and/or water). It was not until Timken was able to analyze the bearing in its labs that the contamination was discovered, though it does not appear to have negatively affected the performance of the bearing. (Due to the proprietary properties of the ES302 coating, the impact to the bearing was minimal.)

INSPECTION SHOWS LITTLE-TO-NO WEAR

After thorough analysis, Timken arrived at the following field performance results for its ES302-coated mainshaft spherical roller bearing that had seen seven years and three

OUTER RING



INNER RING

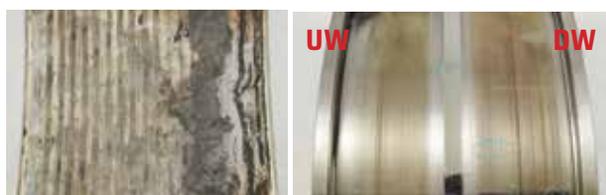


Figure 2: Outer and inner ring inspection showed visible grind lines indicating limited adhesive wear. (Courtesy: Timken)

ROLLERS



Figure 3: Both roller complements were in “very good” condition after operation and maintained their original profile. (Courtesy: Timken)

months service in New Mexico, with the bearing having been last relubricated in 2016. This series of inspections was performed to assess bearing condition after operation. Notably:

- **Grease sample analysis** revealed moderate levels of iron content (attributed to normal raceway wear) and high concentrations of silicon (likely due to the potential contamination event in February 2012). As well, low concentrations of copper were detected, likely due to light wearing of the bearing’s brass cage. Based on particle concentrations, Timken observed only low-to-moderate wear and some evidence of external contamination during grease sample analysis.

- **Inspection of the bearing outer and inner ring** revealed light-to-moderate fretting wear on the outer ring O.D. while the outer race was noted to be in “good” condition (as evidenced by visible grind lines, where a standard mainshaft spherical roller bearing would likely not exhibit grind lines at the same stage of operation). Minor debris denting and lubrication staining (the source of the discoloration in Figure 2) was also observed on the outer race. On the inner ring bore (the surface that contacts the mainshaft), some fretting wear was visible, while the inner raceway, noted to be in “good” condition, showed only minor discoloration and debris denting (possibly due to handling and removal).

- **Bearing roller inspection** (Figure 3) showed that both roller complements were in “very good” condition, with the upwind roller complement exhibiting only minimal distress and light circumferential lining, while the downwind roller complement exhibited light circumferential lining and debris dents.

- **Brass cage inspection** (Figure 4) revealed the cage bridges showed only minor discoloration in the pockets (most likely from the grease) and the complete cage was noted to be in “very good” condition.

- **Quantitative analysis of surface finishes**, meanwhile, showed that outer ring, inner ring, and roller surface finish values were as expected post-operation, with the bearing raceways exhibiting little-to-no adhesive wear, and the upwind rollers showing “very smooth” surface finishes (downwind rollers showed slightly higher surface finishes, likely due to the influence of debris). Critically, all roller profiles were noted to be in “very good” condition, showing minimal signs of wear or deviation from their original profile.

CAGE

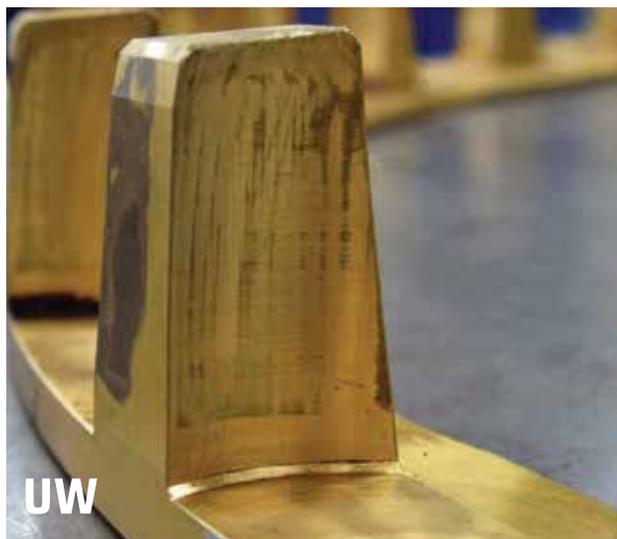


Figure 4: Brass cages offer extra strength in the toughest applications; no cage damage, and only minor discoloration, was observed in the 230/600-series Timken bearing. (Courtesy: Timken)

► **Timken also conducted a hardness test** to ensure that no significant damage was sustained by the bearing surfaces (that is, any major event that would have altered the surface structure of the bearing components, as observed under an electron microscope). This inspection verified that no extreme event occurred; however, analysis did reveal two white etch areas (or “butterflies”) originating from an inclusion or contaminant. In both cases, the white-etch areas were not the result of operating or application conditions and did not contribute to any pre-mature bearing damage.

► **Hardness testing further confirmed** that all bearing surface and subsurface microstructures, which were thoroughly hardened, matched the expected outcome for the material and heat-treatment methods applied, indicating there was no significant change in bearing metallurgy during operation.

IN SUMMARY

After seven-plus years of service, the Timken ES302-coated mainshaft spherical roller bearing installed in the 3-point turbine in New Mexico showed little-to-no adhesive wear, demonstrated the expected surface finish, and remained consistent with the original design profile, leading Timken to conclude the bearing was in “very good” condition for this stage of operation. Furthermore, there was no evidence of the bearing entering the next stages of damage. Based on its own application engineering practices, Timken can confidently estimate the bearing would have continued to provide reliable, trouble-free operation into the 15- to 20-year time frame had it not been taken out of service.

As U.S. turbine fleets continue to age, Timken will have access to more field data to compare the performance of different ES302-coated bearings. Presently, there are more than 1,000 such bearings helping to power a brighter future

around the world, with a solid track record for performance and durability proven in the lab, and now in the field.

If bearing failures are a mounting concern for your wind farm, Timken experts, who have engineered stronger solutions for the world’s largest turbines for decades, can bring a unique insight and analysis to the problem. In addition to special coatings for mainshaft bearings, Timken has developed a full portfolio of wind bearing solutions and surface treatment options, all designed to help turbines go the distance without the downtime.

ABOUT THE STUDY

The Timken Company has sold bearings to the wind-energy industry for more than a decade, including ES302-coated mainshaft spherical roller bearings that first entered service in North America in 2011. While initial testing indicated the bearings would perform well under real-world conditions, field results have been difficult to obtain. Recently, a non-bearing-related changeout of a turbine drivetrain gave Timken scientists the opportunity to inspect one of these bearings and compare the results to the expectations for a bearing at this stage of service, more than seven years later. The ES302 coating, which received an Engineering Materials Achievement Award from ASM International in 2017, is a proprietary Timken technology not offered by any other competitor, and these are the first reported field results for the coating on a mainshaft spherical roller bearing application. ↘

ABOUT THE AUTHOR

Caleb Chovan is a senior wind bearing application engineer for The Timken Company. Caleb works with original equipment and aftermarket customers with a focus on mainshaft bearings. For more information, visit www.timken.com/wind-energy.

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PROFILE

NRG SYSTEMS, INC.

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A Spidar Vertical Profiler.
(Photos courtesy: NRG
Systems, Inc.)

The image features a close-up of a white, cylindrical NRG Systems Spidar Vertical Profiler mounted on a black tripod with red joints. The profiler has a red handle and the NRG Systems logo (a stylized green and yellow leaf) and the text "NRGSystems." on its side. In the background, a field of tall grass is visible under a blue sky with scattered clouds, and several white wind turbines are scattered across the horizon.

NRGSystems.

By offering pre-construction and post-construction solutions, NRG Systems, Inc. helps its customers secure the lowest possible financing rates for their prospective wind projects, and ensures those projects keep running efficiently after they go live.

By **KENNETH CARTER** ▶ Wind Systems editor

A wind farm is essentially a large power plant that can end up costing millions of dollars. Financing that wind farm usually involves two important pieces: assessing the energy available at the anticipated location and determining the type of equipment that will be used to capture that energy.

NRG Systems, Inc. has been helping wind developers with the first piece of that puzzle for more than 36 years.

“Our primary role is to help wind developers ‘de-risk’ their projects so they can achieve the lowest possible financing rates,” said David Hurwitt, vice president of Global Marketing and Product Management for NRG. “If you’re a banker trying to put money to work in a wind farm, the way you get paid back is by that wind farm producing as much energy as you predict it’s going to produce. If you’re uncertain about the answer to that question, that creates more risk, which leads to higher rates, a more expensive project, and more expensive electricity. By creating better sensors and more accurate resource assessment technology, we are helping developers collect reliable data, which ultimately leads to less risk and less expensive electricity.”

NRG has spent decades perfecting its technology for wind measurement, as well as building relationships and developing its manufacturing capabilities, all while expanding globally with the industry, according to Hurwitt. Those developments created a niche market for NRG that led to the company being involved in about two-thirds of all wind development on the planet.

“We started in the early ’80s putting up towers and anemometers,” he said. “We have spent a lot of time perfecting those things. We make taller towers. We make more sensitive anemometers and other sensors. About a decade ago, we helped pioneer the introduction of Lidar into the wind measurement space when we became a distributor for one of the early Lidar manufacturers working in the wind-energy market.”

LIDAR ADVANCEMENTS

In 2018, NRG acquired its own Lidar technology, Spidar, from an Israeli company (Pentalum Technologies), in order to develop that technology further and bring it to every market in the world. What sets Spidar apart is its use of Pulsed Direct Detect Lidar technology to deliver precise, bankable wind-measurement data at a significantly lower cost than conventional Doppler Lidar, according to Hurwitt.

“Lidar has mostly been a developed-world solution,” he said. “It’s expensive and is often too costly for measurement campaigns in most areas of the world. If you go to parts of China, India, Southeast Asia, Latin America, they use very tall met towers because they are still reasonably inexpensive.”

But with the introduction of low-cost Lidar options, Hurwitt said Lidar will become more competitive with towers in developing markets.

“It’s going to be a real game changer for us as we start to bring Lidar to the rest of the world, and we’re really excited about rolling that product out in the next year,” he said.

TAKING CARE OF CUSTOMERS

Having the proper technology and equipment is important, to be sure, but it ultimately means nothing unless potential customers are cultivated and taken care of properly, according to Hurwitt.



A customer-training at NRG’s headquarters in Vermont.

“NRG is a very customer-centric organization,” he said. “We believe passionately in the mission of what we do. But all of our customers already believe passionately in the mission because they are renewable-energy companies. Once you realize that you’ve got kindred spirits, then it’s a question of: How well are you listening to those people? So we spend a tremendous amount of time across our organization in the field with our customers — literally in the field — helping them to tilt up towers and make adjustments to products. We spend time on the phone with them. We go visit them in their offices. We help them analyze data. We really think that the wind industry, like most industries, is best served when you’re really listening to



A Bat Deterrent System being installed in Hawaii for testing.

your customer and responding to them.”

Part of that customer success is simply because NRG is easy to deal with, according to Hurwitt.

“We put a premium on simplicity,” he said. “We recognize that a lot of the things that our customers go through is really hard, and working with us shouldn’t be one of those things. If you’re developing a \$100 million wind project, you’ve got a fair amount of pressure built into the system, so you need to make sure that the products that you’re buying from us are easy to understand, easy to order, quick to receive, with a limited amount of packaging, because if you’re putting a met tower up on a remote location in Thailand, you might have to pack that equipment on donkeys.”

“We make sure that you have all the right tools – that you have standard size bolts, everything that you would think of to make your life easier to both acquire, own, operate, and service all of your products,” Hurwitt said. “So, keeping it simple and thinking it through from a customer’s perspective, I think, is a distinguishing factor for us.”

ENVIRONMENTAL FOOTPRINT

Being involved in renewable energy also means NRG is heavily involved in making a better future for the planet, according to Hurwitt.

“We have been a leader in the environmental side of

wind-farm development for a long time,” he said. “We helped found an industry association called the American Wind Wildlife Institute.”

Through that organization, NRG partnered with two other organizations to develop technology to keep bats away from wind turbines, according to Hurwitt.

“At our customer’s request, because they recognize us to be the easy-to-do-business-with company that I mentioned, as well as a company that has a tremendous amount of experience helping to create products that last in harsh operating environments and work effectively with wind turbines, we are getting ready to commercialize our Bat Deterrent System,” he said. “The pioneering technology essentially creates an ultrasonic field around the rotor-swept area of a turbine that effectively ‘jams’ the echolocation capabilities of bats, which they rely on for communicating, orienting, and foraging. If the bats can’t echolocate around wind turbines, they will realize that it’s not productive feeding for them and turn away, ultimately making their way to safer airspaces.”

POST-CONSTRUCTION

Whereas much of NRG’s early history dealt with the pre-construction side of wind, the company has expanded into the post-construction side by helping its customers

make turbines operate more efficiently.

“On the post-construction side, we make turbine-control sensors, which go on turbines and help them to operate at peak efficiency,” Hurwitt said. “And we’re looking at a range of other products that we can bring to that market to help existing assets run more efficiently. As the installed base grows, so grows the demand for O&M. And not just for sensors that work better, but sensors that help you to identify ways to increase your power production. That’s a focus area for us, and you’ll see some new things coming from us in the future on that.”

On that note, wind isn’t going anywhere, and the positive message and results wind energy have to offer will continue to grow, according to Hurwitt.

“The industry, I would say, will be the most common energy source out there,” he said. “It will be widely recognized as both the lowest cost and the most environmentally friendly source of energy. And the average consumer’s perceptions on wind have greatly improved, and I think that will only get stronger. Non-utility off-takers, the commercial off-takers, the corporate off-takers of the world, are doing a terrific job in helping to bridge that gap between the utility industry and the average consumer. That trend will continue and be very positive for wind.”

And NRG expects to continue to capitalize on that as the industry grows, according to Hurwitt.



NRG tower installation in Mongolia.

“We’re going to be a much more diverse company than we’ve been,” he said. “We’ll be servicing people, as we’ve been doing, all over the world, but we’ll have a range of products in both pre-construction and post-construction, and we’ll be bringing new technologies like Lidar and ultrasonic bat deterrence and some other new things to the market, including solutions that people haven’t even conceived of today.”

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The advertisement features a large image of a red aerial lift platform extending from the ground to a worker on a wind turbine. The lift has "Abilene High Lift Aerial" written on its side. In the top left corner, there is a logo with a stylized wind turbine and the text "ABILENE HIGH LIFT AERIAL". The bottom of the ad is a red banner with white text providing contact information.

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The advertisement features a background image of a wind turbine with a drone flying in front of it. In the top left corner, there is a circular logo with a drone and the text "THERMAL CAM USA". The text "THERMAL CAM USA" is also written in large red letters to the right of the logo. The main headline "LEADERS IN THE DRONE SERVICES INDUSTRY" is in large white letters. Below this, there are two paragraphs of text describing the company's services. The bottom of the ad is a red banner with white text providing contact information.



Ben Moss

Senior Projects Director ▸ New Energy Update

“Business gets done at Wind O&M Dallas, and that creates an excitement and buzz that people thrive off.”

▸ How did Wind O&M Dallas begin, and how has it changed over the years?

Wind O&M Dallas (April 16-17, 2019) started out in 2008 (in Dallas still) with a handful of attendees and just five exhibitors. Since then, the event has grown into a key meeting point for the wind-energy industry, expanding to 700 attendees and 75 exhibition booths in 2019.

▸ What is your role with the show?

My role as the project director is to research the topics, create our agenda, recruit the speakers, and to oversee the marketing and sales activities of the team working alongside me on the event. It's pretty full on!

▸ What went into planning this year's show?

We started researching the topics for the event in August 2018 and did over 150 hours of research calls with the industry to find out what the hot topics are right now. We mostly speak to the owners and IPPs, the OEMs, and the greater supply chain to understand what keeps them up at night and what O&M innovations they're excited about.

From there, we created an agenda that reflected those topics and began our speaker recruitment. New Energy Update doesn't do a call for papers; we prefer to go after the people that our audience selects as the experts in their field and ensure they are at the event.

▸ What did you learn from last year's show that helped in planning this one?

We ask for a lot of feedback from our audience following the event, and we got an amazing amount surrounding the agenda topics. It gave us great insight into where our audience's focuses were moving to. As an example, most of the owners said they'd want to hear more about energy storage, so we included that for the first time ever as a dedicated session. Not only that, but we found that many asset owners had PV portfolios, so for those working in PV, we have also launched Wind Dallas' sister PV O&M event, which will be held at the same date and location for those who wish to attend both.

We also heard more about the importance of actual knowledge sharing, rather than pure commercial adverts, so we have incorporated many more intimate networking functions that will allow for a greater depth of knowledge sharing across all companies in attendance.

▸ How does Wind O&M Dallas differ from other wind-energy trade shows?

The event has been running now for 11 years, but we've always been an intimate networking event where our attendees will only rub shoulders with key decision makers from the industry. We're expecting around 700 people, 300 of which will be the asset owners themselves, and they're mainly the senior site managers, directors, VPs, and C-suite level attendees, so you know you'll meet the right people.

Our pledge to our audience is that while you may not be in the room with thousands of people, you'll be in the room with the right people. Beginning and fostering partnerships, sharing case studies in O&M successes and hitting on the pain points that keep you up at night.

▸ What will attendees expect to see?

Business gets done at Wind O&M Dallas, and that creates an excitement and buzz that people thrive off. People really enjoy the show and how close-knit the attendee community is; it makes for a better networking experience at the end of the day. You won't be searching through crowds of thousands of people trying to meet the people you want to meet.

Not only that, but we have many interactive working group style sessions where we'll get the audience involved in discussing the pressing challenges and exciting opportunities facing the industry today. There'll be plenty of opportunities for you to share your expertise with the audience both during the sessions and in the networking breaks.

▸ What's new at this year's show?

We've made some pretty big changes based off the feedback from the industry. Most notably for the wind event is that we're adding in exciting new sessions such as supply chain



Wind O&M Dallas is an intimate networking event where attendees will only rub shoulders with key decision makers from the wind industry.

and logistics, workforce development (recruit, train, retain), data driven O&M, and our brand-new innovation showcase. We're focusing on innovation and opportunity throughout the agenda, so it won't be same-old, same-old.

We've also worked hard to make sure that there is representation from every medium- to large-scale asset owner in North America. With an expected turn-out of 300 executives from utilities, IPPs, and infrastructure funds, including job functions that range from the C-suite to managers (asset,

▾ **We've always been an intimate networking event where our attendees will only rub shoulders with key decision makers from the industry.** ▾

site, engineering, technical), supply chain and procurement teams, and finance.

▾ **What are you personally looking forward to at this year's show?**

The technology innovation showcase for sure. Simply put, it's a TED-talk/*Shark Tank* style pitching session where participants showcase the latest and greatest innovations in the Wind O&M industry and exactly how it will make everyone's lives much easier. Our judging panel (APEX, Liberty Power, Excelsior Energy Capital) will then give feedback on what they liked and perhaps didn't like. We'll also get the audience involved, so you can put your thoughts forward, too. It's a session we have done recently in many other events, and the audience really loves it. We hope ours does, too! 🙌

MORE INFO ▾ newenergyupdate.com



The SG 3.4-132 onshore wind turbine is the most profitable product in its segment. (Courtesy: Siemens Gamesa)

MANUFACTURING

Siemens Gamesa awarded 28-MW order for a Voltalia project

Siemens Gamesa Renewable Energy recently signed its third contract with Voltalia in Brazil to supply the wind project Ventos da Serra do Mel 2 (VSM 2).

The scope of the contract with Voltalia, recognized international player in renewable energy with a presence in 18 countries, includes the supply of 36 units of the SG 3.4-132 wind turbine model with a flexible power rating of 3.55 MW for the VSM 2 wind complex in Rio Grande do Norte, northeastern region of Brazil, for a combined total nominal capacity of 128 MW. Commissioning of VSM 2 is planned for 2020.

This is the third contract signed with Voltalia in Brazil following Vila Acre I (27 MW, 13 units of SG 2.1-114) and Ventos da Serra do Mel 1 (163 MW, 47 units of SG 3.4-132). In total, Siemens Gamesa has been awarded a total of 318 MW by Voltalia in Brazil since 2016.

“Our customers’ trust is fundamental to enable and drive our growth strategy, and we are very pleased to have received this third order from Voltalia,” said Roberto Prida, managing director Onshore Brazil. “We feel very confident that together we are advancing wind power as the most competitive generation technology in Brazil.”

“Siemens Gamesa is a trusted partner for the supply of wind turbines and we are glad to continue our partnership with them to build new projects,” said Robert Klein, CEO of Voltalia

Brazil. “We have a great confidence in Siemens Gamesa’s equipment and capabilities.”

Since 2012, Siemens Gamesa has provided more than 3.1 GW (more than 1,500 units) of output capacity for close to 60 project sites across Brazil. The company has a strong footprint in the country consisting of manufacturing, service, and offices.

The SG 3.4-132 onshore wind turbine is the most profitable product in its segment, featuring optimal Levelized Cost of Energy (LCOE) for medium and high winds, rotor diameter of 132 meters, a flexible power rating of 3.3-3.75 MW depending on the project requirements, and low-risk based on proven technologies and enhanced performance with the highest levels of reliability.

MORE INFO www.voltalia.com

MANUFACTURING

Vestas introduces innovative modular platform

Vestas has been at the frontier of wind energy for 40 years, introducing market-leading wind energy solutions that have driven down the cost of energy and taken wind energy from niche to mainstream. Vestas recently introduced the EnVentus wind-turbine platform, which represents another significant step forward in the continuous efforts to lower the leveled cost of energy and accelerate the global transition to a more sustainable energy mix.

The EnVentus platform will initially be available in two new variants: the V150-5.6 MW and V162-5.6 MW, together covering low-, medium-, and high-wind conditions. Based on advanced modular design, EnVentus supports Vestas' vision to become the global leader in sustainable energy solutions and provides a wider range of turbine configurations that can better meet evolving customer needs.

EnVentus represents the next generation of wind-turbine technology and connects four decades of wind-energy innovation with the experience and

knowledge represented by Vestas' 100 GW of installed wind turbine capacity. The new platform demonstrates the benefits of Vestas' industry-leading investments in R&D and unmatched volume of wind data.

"EnVentus is a great achievement by everyone at Vestas that allows us to meet customers' increasing needs for customization and continuous reduction of the cost of energy," said Anders Runevad, Vestas President and CEO. "Our relentless focus on delivering industry-leading revenue and profitability the past years has given us the resources to develop a new platform built on our world-class R&D. Following our 2018 order record and 100-GW milestone, EnVentus is another important step in Vestas' journey to become the global leader in sustainable energy solutions."

As Vestas' first platform introduction since 2011, EnVentus combines proven technology and system designs from Vestas' 2-MW, 4-MW, and 9-MW platforms with advanced modularity, building a foundation that reliably and efficiently lowers the cost of energy. The journey towards a modular platform was initiated in 2012 and is expected to create increased scale advantages and opportunities to optimize current and future value chain needs, such as design cycles and transportation.

"Vestas has pioneered wind energy since 1979 and, by introducing EnVentus and its first two variants, we connect heritage with innovation to underline our technology leadership," said Anders Vedel, Vestas chief technology officer.

"With the introduc-

tion of a platform built on advanced modularity, we increase our ability to provide customized solutions while ensuring value chain optimization. I'm incredibly proud of everyone in Vestas who has been part of developing our new platform and variants, once again showing Vestas has the most passionate and innovative minds in the industry."

The platform's first two variants: the V162-5.6 MW and V150-5.6 MW will be globally applicable and are added to the wide range of Vestas' existing 2-MW and 4-MW platform turbines, giving customers an unmatched combination of turbines to harness wind in any specific location. The turbines feature a full-scale converter, capable of meeting complex and differing grid requirements in local markets. The full-scale converter is matched by a permanent magnet generator for maximum system efficiency and balanced by a medium-speed drivetrain.

With a swept area of more than 20,000 square meters, the V162-5.6 MW offers the largest rotor size in onshore wind to achieve industry-leading energy production. When paired with a high capacity factor, the V162-5.6 MW offers 26 percent higher annual energy production than the V150-4.2 MW, depending on site-specific conditions. It is primarily relevant in low-to-medium wind conditions, but it also has extensive applicability in high average wind speeds depending on site-specific conditions. The first V162-5.6 MW prototype is expected to be installed in mid-2020, with serial production later that year.

The V150-5.6 MW takes Vestas' existing 150-meter rotor and applies it to higher wind speeds and extended market applicability. When combined with its higher generator rating, the turbine increases the annual energy production potential by 30 percent compared to the V136-4.2 MW, depending on site specific conditions. It is primarily relevant in medium to high wind conditions. The first V150-5.6 MW prototype is expected to be installed



The V150-5.6 MW is one of two variants for the EnVentus platform. (Courtesy: Vestas)

in the second half of 2019, while serial production is scheduled for mid-2020.

Initially, the new variants are targeted at the onshore market, but may have offshore applicability.

The name EnVentus combines “energy,” “environment,” “invent,” and the Latin word for wind “ventus” to encompass the company’s pioneering and innovative heritage within wind energy and aspiration to lead the global transition to a more sustainable energy system.

MORE INFO www.vestas.com

► CONSTRUCTION

U.S. installs 5.9 GW in fourth quarter of 2018

The U.S. wind sector installed 5.9 GW of new capacity in the fourth quar-



About 16.5 GW of wind projects were under construction at the end of 2018, with a further 18.6 GW in advanced development. (Courtesy: New Energy Update)

ter of 2018 to bring the total for the year to 7.6 GW, an 8 percent increase on 2017, the American Wind Energy Association (AWEA) said in a report published January 30.

Wind operators completed 909 MW of partial repowering projects in the fourth quarter for an annual repowering total of 1.3 GW, AWEA figures showed.

The U.S. is forecast to install 10.9 GW wind capacity in 2019 — the highest level since 2012 — as developers race to meet production tax credit (PTC) deadlines, the Energy Information Administration (EIA) said in its latest Short-Term Energy Outlook published in January. The wind installation forecast represents a 3-GW increase on the 2019 projection set out in EIA’s 2018 Annual Energy Outlook.

More than half of the new wind capacity additions will be in Texas, Iowa, or Illinois, and most of the capacity will come online toward the end of the year, EIA said.

About 16.5 GW of wind projects were under construction at the end of 2018, with a further 18.6 GW in advanced development, AWEA said in its report. The combined total of 35.1 GW was up 22 percent year-on-year. About 20 percent of this activity was in Texas while other prominent states included Wyoming, Iowa, South Dakota, and New Mexico, AWEA said.

GE Renewable Energy reclaimed the top spot for turbine manufacturers in 2018, installing 40 percent of U.S. wind turbines by capacity. Vestas installed 38 percent of capacity while Nordics USA held 11 percent of the market and Siemens Gamesa held 8 percent.

Most of the turbines installed were of capacity between 2 MW and 3 MW while 24 percent were more than 3 MW, AWEA said.

In October, GE unveiled a new 5.3 MW turbine that incorporates 77-meter blades and hub heights of up to 160 meters.

MORE INFO newenergyupdate.com

► CONSTRUCTION

Global Wind Service to assemble towers for East Anglia ONE

Siemens Gamesa Renewable Energy has contracted wind-turbine installation and service company Global Wind Service to assemble 102 towers for East

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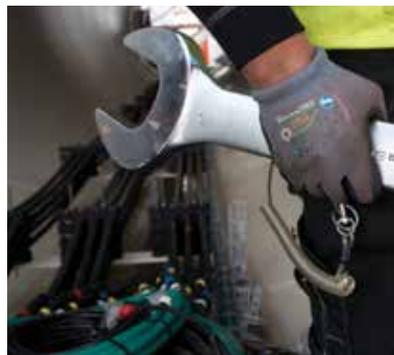
Anglia ONE Offshore Wind Farm in the U.K. The towers will be assembled at the Norfolk port of Great Yarmouth, only half an hour drive from GWS' office in Lowestoft, ahead of their load-out and installation offshore as part of the wind-farm construction.

The pre-assembly work of the SWT-7.0-154 turbines is scheduled to commence at site mid-March 2019 and expected to run for a year. For the 66kV high voltage scope, GWS will be drawing on the specialized HV-technicians from GWS' joint venture Delpro Wind.

East Anglia ONE is in the Southern North Sea, approximately 43 kilometers off the Suffolk coast. Once in full operation in 2020, the installed power capacity of 714 MW will be supplying green energy to about 600,000 British households. As such, it will be one of the largest offshore wind-power plants in the world built on an investment of about 3 billion euros.

East Anglia ONE will be the first wind farm project to use 66kV cables on a commercial scale. This higher rating is expected to be the dominating technology for future offshore projects in an effort to reduce the loss of energy during transmission.

"Global Wind Service is very pleased to be part of this world-leading project together with our strong partner through 10 years, Siemens Gamesa," said Michael Høj Olsen, chief commercial officer at GWS. "We have been present in the U.K. for over nine years now, so this is a great way for us to underline our strong and continuous



East Anglia ONE will be the first wind farm project to use 66kV cables on a commercial scale. (Courtesy: Global Wind Service)

commitment to the country's offshore wind market. A long-term project like East Anglia ONE is supporting GWS' strategy to continue our growth globally and in the U.K. where it will also create more local jobs, which is great for the UK wind industry."

"For a ground-breaking project like East Anglia ONE, it was important to choose a supplier with solid experience and expertise as well as prov-

en quality and safety record," said Andrew Elmes, senior project manager for SGRE. "With GWS' in-house high-voltage competences in Delpro Wind, along with over nine years of local presence in the U.K. market, we have selected a strong partner for this project, and we are happy to continue our long-term cooperation with GWS."

MORE INFO www.globalwindservice.com

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CONSTRUCTION

Collett delivers blades to Kype Muir wind farm

Using its Nootboom triple extendable Super Wing Carriers, Collett recently delivered 78 turbine blades (26 turbines in total) destined for Kype Muir Wind Farm.

Collett's teams undertook the planning and delivery of 494 components including blades, towers, nacelles, drive trains, and hubs required for the development of Kype Muir Wind Farm. The 80-meter hub height towers of the Senvion 3.4MW turbines feature 52-meter blades, and while these are not the largest the company has been appointed to handle, they necessitated the use of its Super Wing Carriers due to the problematic road restrictions and alignments en-route.

Several areas of route modifications were identified ahead of the project — including bridge restrictions — with an emphasis on the Lambhill Road and Brown's Bridge areas on approach to the site. Excluding the loaded wind-turbine blades, each of the components would be loaded to a combination of

3-, 4-, 5-, and 6-axle stepframes, modular low loaders, and clamp trailers for transportation to the site. With the planned route modifications — including removal of vegetation, road signs, and road widening — already having been completed, this did not pose challenge to navigate.

The challenge arose when it came to the transportation of the 52-meter blades, which is where Collett's Super Wing Carriers came into effect. The use of these specialist trailers provided the ability to shorten the body and wheelbase of the trailer while loaded with the use of the bolster arrangement on the trailer deck. Using the features of these Super Wing Carriers, extendable up to 64.3 meters, meant that the proposed access route to the development site became a viable option for this size of turbine.

Proof of this flexibility was demonstrated prior to transport by Collett Consulting creating a 3D model of the loaded vehicle. This then allowed Collett to produce a detailed swept-path analysis video of the blade components, successfully negotiating restricted route sections by manipulating the trailer while loaded.

This in-depth planning allowed Collett to highlight the sections of the

route where the steering angle of the Super Wing Carrier's bogie provided extra maneuverability. The challenge was to ensure there would be no contact with any part of the blade or the trailer chassis with the road surface, bridge structures, or buildings when navigating several sections of the route. This is where capabilities of the Super Wing Carriers to raise the trailer height came into action, allowing Collett to raise the height of both the front and the rear of the trailer, resulting in each of the blades oversailing the embankments and stone parapets when crossing the bridges en-route. By employing the capabilities of these trailers, Collett was able to remove the need for further, more costly modifications, and ensure that each of the 78 52-meter blades would safely arrive.

The 18-week delivery schedule that began in July is now complete. Following an agreed timetable of 1.5 turbines per week, Collett systematically transported each of the 494 cargoes from their portside location direct to the delivery site. Working on a multi-port strategy with components arriving at the Port of Grangemouth and King George V Dock, the Collett team has undertaken all ship's discharge and stevedoring duties, port storage, extensive planning and delivery for each complete turbine.

Deliveries to the site, three miles south of Strathaven, South Lanarkshire, are now completed and construction of the wind farm is underway. Kype Muir Wind Farm is the flagship development of Banks Renewables and is expected to be fully operational in early 2019.

MORE INFO www.collett.co.uk

INNOVATION

Sulzer Schmid slashes cost of drone inspections

Sulzer & Schmid Laboratories AG, a Swiss company pioneering next-generation technology for the inspection of



Super Wing Carriers can vary the trailer height, allowing Collett to raise the height of both the front and the rear of the trailer, resulting in each of the blades oversailing embankments and stone parapets when crossing bridges. (Courtesy: Collett)



Based on the compact and flexible DJI M-210 drone, Sulzer Schmid's latest innovation delivers high performance and fully autonomous drone inspections. (Courtesy: Sulzer Schmid)

wind-turbine rotor blades, recently announced it has launched a new highly competitive inspection platform. The company's new 3DX™ HD product has been developed as a cost-effective solution to cope with large volumes of high-definition blade inspections.

Based on the compact and flexible DJI M-210 drone, Sulzer Schmid's latest innovation delivers high performance and fully autonomous drone inspections at a significantly lower cost, compared to its existing 3DX™ Ultra-HD product based on the DJI's M-600 drone.

Thanks to the new capabilities offered by unmanned aerial vehicles, the market for drone-based rotor blade inspections has boomed in recent years.

"Our technology produces high-definition image quality that is superior to any other inspection method," said Tom Sulzer, co-founder of Sulzer Schmid. "Our drone inspections offer a myriad of benefits: They are automated and, therefore, immune to human error, repeatable, and consistent in quality while covering 100 percent of the blade. Most importantly, the fully digital end-to-end process creates a foundation for trend analysis and predictive maintenance."

Depending on the type of inspections and their requirements, wind

turbine OEMs, wind asset owners, and O&M service providers will now be able to choose the technology that best suits their needs. Whereas critical

inspections, such as end-of-warranty or change of ownership, call for the superior images provided by the 3DX™ Ultra-HD product, regular inspections can now be carried out with great efficiency by the 3DX™ HD platform at a fraction of the cost.

The new 3DX™ HD product combines increased inspection capacity with improved ease of deployment. It offers all the key benefits of autonomous inspection flights, while improving inspection efficiency, handling, and deployment during field operations. It is compact enough to be checked-in as regular luggage for air travel and can be deployed easily on CTV ships for Offshore Wind inspections.

"We are pleased to deliver a new solution that addresses our customers' needs for high-volume and routine blade inspections," said Christof Schmid, co-founder of the company. "We always push the envelope by increasing automation in all steps of the



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inspection workflow and by increasing the robustness of our products. We also continue to expand our product range, and we expect to launch our new offshore inspection solution later this year.”

MORE INFO www.sulzerschmid.ch

INNOVATION

Bazefield software manages 23 GW of renewable energy

Bazefield has had strong growth in the wind and solar domain.

Bazefield software manages 23 GW on installations across 23 countries. This includes sites in Europe, North America, South America, and Asia.

The system is in use by a range of notable clients including EDF Luminus, ReNew, Brookfield Renewables, ConEdison, Equinor, and more. Bazefield is the state-of-the-art product when digitalizing renewable energy O&M.

The Bazefield software is the most flexible and comprehensive off-the-shelf system in the market. The system is scalable from a single farm to large portfolios, and it captures real-time data, monitors and control assets and sites, includes several tools for visualization, predictions, and analysis based on machine learning and others. Bazefield further supports



The Bazefield software is the most flexible and comprehensive off-the-shelf system in the market. (Courtesy: Bazefield)

workflow and task management and provides overviews and operational real-time performance reporting. This also includes flexible dashboard design functionality and support for portable devices.

MORE INFO bazefield.com

INNOVATION

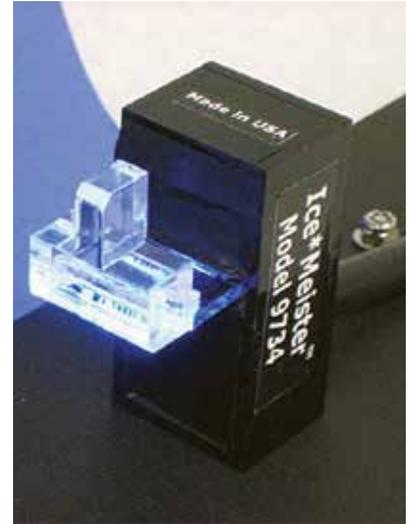
Global distributor, sensor maker modernize ice sensors

Wind Cluster ApS, global distributor of wind-turbine components and accessories, together with New Avionics Corp, leading maker of modern optical ice sensors for industry and aerospace, recently announced the two companies have signed a distribution agreement covering modern ice sensors for wind-turbine manufacturers, operators, and energy companies throughout Europe, China, and India.

In Europe and Asia, Wind Cluster is a one-stop shopping center for turbine manufacturers and operators, offering a wide variety of components and accessories to the global wind power industry. Wind Cluster operates through a network of offices in Denmark, China, and India.

In Florida, New Avionics has developed the Ice[®]Meister™ line of NASA-tested optical ice sensors for aerospace and industry, where the need is to sense hazardous ice and take corrective action. These are demonstrably the smallest, lightest, most-sensitive ice detectors for wind-power turbines, unmanned aerial vehicles, commercial refrigerators and heat pumps, HVAC cooling towers, radio and TV broadcast towers, autonomous commercial drones, vehicular bridges and overpasses, oil and gas sites, etc.

“Ice detection is a necessity for optimum power production and safety in many countries,” said Peter Nyegard Jensen, CEO of Wind Cluster. “Until now, solutions have been complex and expensive. Therefore, we are



New Avionics has developed the Ice[®]Meister™ line of NASA-tested optical ice sensors for aerospace and industry, where the need is to sense hazardous ice and take corrective action. (Courtesy: New Avionics)

happy to introduce the products and unique expertise of New Avionics to the industry.”

“New Avionics is extremely pleased to sign this agreement with Wind Cluster for distribution of our ice sensors,” said Richard Hackmeister, CEO of New Avionics Corp. “This pact helps turbine manufacturers and operators maximize operational efficiency during icing conditions, at the lowest possible sensor cost. We look forward to a long and productive relationship with the hardest-working distributor of wind-power components and accessories.”

MORE INFO www.newavionics.com

MAINTENANCE

U.K. wind firms push investment in masts and monitoring

Dulas, a leading renewable energy consultancy, recently announced its wind monitoring division saw an uptick in work from new and existing clients in 2018, as the business sup-



The bulk of the Dulas' work in 2018 came from meteorological mast installation, refurbishment, and decommissioning. (Courtesy: Dulas)

ported more than 30 wind companies in managing their meteorological mast and remote sensing services across their wind portfolios.

The bulk of the firm's work came from meteorological mast installation, refurbishment, and decommissioning, as clients either replace or upgrade their monitoring, or site new masts for future wind project development.

As highlighted in the recent Dulas report, *Enhanced Data and Enhanced Returns: Getting the Best From Wind Monitoring Technology*, wind speeds are directly proportional to project returns, a crucial factor continuing to drive investors planning post-subsidy wind projects.

Alongside onsite work undertaken by Dulas, asset owners increasingly turned to data services in 2018, allowing them to streamline resource reporting as well as anticipate and pre-empt operations and maintenance (O&M) costs. Dulas performed data services for nearly 30 percent of its wind-monitoring client-base.

"While recent U.K. government decisions on support for renewable energy – notably onshore wind – have significantly and negatively affected the pipeline for future development, it is encouraging that there are developers in the industry looking

carefully at how to make future project economics stack up," said Rachel Munday, commercial lead for Wind Monitoring at Dulas. "Key to this, of course, is the quality of data provided in early stage resource assessment by meteorological masts and remote sensing from Sodar and Lidar."

"Furthermore, the increase in volume of work we've seen at Dulas is likely testament to existing asset owners investing in securing their future returns, optimizing their projects using meteorological mast data," she said.

2018 additionally saw the expansion of Dulas' services into Europe, with the business undertaking remote sensing work for U.K.-based clients in Scandinavia.

MORE INFO www.dulas.org.uk

MAINTENANCE

Zero-Max tool offers pre-set torque value

The Zero-Max Torq-Tender™ is an enclosed device with no external adjustment features. It has a pre-set torque value and, once installed, cannot be changed. This feature safeguards

against improper or unauthorized torque adjustments.

Designed to avoid system damage, Zero-Max Torq-Tenders provide dependable overload protection. When a jam-up or excessive loading occurs, the built-in Torq-Tender will reliably and quickly release to prevent system damage. Proper torque setting ensures the machine operates and reacts the way it was intended. The Torq-Tender's pre-set torque with no external adjustment feature, ensures the proper torque setting is maintained.

Additional Zero-Max Torq-Tender features include:

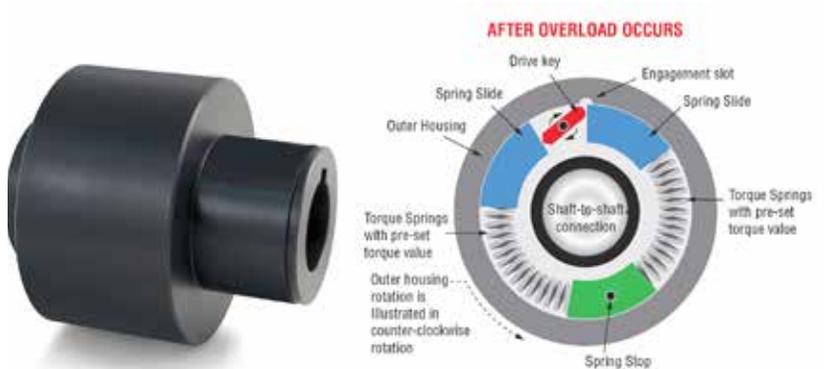
- Standard Torq-Tenders are bi-directional. Torque values remain the same regardless of rotation.

- If specified, the Torq-Tender can be configured at the factory to release at different torque ratings for different rotational directions.

- When used as a coupling, the Torq-Tender fulfills two functions: as a flexible shaft coupling and as a mechanical torque limiter.

- Designed with heat-treated steel, Zero-Max Torq-Tenders are manufactured and assembled to operate in a wide variety of demanding industrial environments. Special designs and finishes are available to withstand the most adverse operating conditions.

MORE INFO www.zero-max.com



Zero-Max Torq-Tender™ (left) have torque springs with pre-set torque value (right). When system jam up or overload occurs, the Torq-Tender releases at the pre-set torque value.

A large roll of copper wire is the central focus of the image. The wire is tightly coiled, creating a dense, textured pattern of overlapping loops. The color is a rich, warm copper. In the top left corner, there is a dark blue banner with white text. Another smaller banner is partially visible below it.

CROSSWINDS

THE FUTURE OF WIND

**SHOWING
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As more wind projects enter the pipeline, the need for copper also grows.

By **KENNETH CARTER** ▸ Wind Systems editor

Humans have been making things from copper for more than 8,000 years. Through the centuries, this versatile, highly conductive metal has gone from being a key ingredient that helped birth the Bronze Age to the Modern Age, where it has become an essential element in the functioning of green-energy systems, including wind plants.

“Wind power is becoming a major player in North America as society transitions to cleaner, more sustainable practices,” said Zolaikha Strong, director of energy policy and electrical markets for the Copper Development Association.

As new onshore and offshore wind installations continue to be built from coast to coast, reliable, conductive, and flexible materials are needed to support the complex electrical infrastructure within these systems.

“You can’t just add more fuel to a wind turbine,” Strong said. “Wind plants rely on weather, so its infrastructure must be able to withstand harsh conditions to effectively support transitions of power generation. Copper is the most conductive metal to meet these demands, and its efficiency ensures that reliability is met in supporting onshore and offshore wind installations.”

OFFSHORE POSITIVES

With the growth of offshore wind installations, copper is an even more significant material component, according to Strong.

“You can’t put a turbine in the middle of New York City,” she said. “But you could build off the coast and export that electricity using underground transmission lines into Manhattan, the other boroughs, or a populous state such as New Jersey.”

▼ In comparison to onshore wind plants, offshore farms depend on underground transmission to interconnect the wind facilities to land. Copper is a necessity for the cabling/wiring itself, but it's also critical for handling the system's resilience. ▼



Wind plants rely on weather, so their infrastructure must be able to withstand harsh conditions to effectively support transitions of power generation. Copper is the most conductive metal to meet these demands. (Courtesy: Copper Development Association)

This approach demands advanced wiring installations that can handle large energy flows and power transitions since it's very difficult to fix issues buried in the ocean, according to Strong.

"In comparison to onshore wind plants, offshore farms depend on underground transmission to interconnect the wind facilities to land," she said. "Copper is a necessity for the cabling/wiring itself, but it's also critical for handling the system's resilience."

COPPER VS. ALUMINUM

As the construction of wind farms continues, other materials, such as aluminum, have been discussed as copper substitutes; Strong believes copper is still the superior choice.

"Aluminum doesn't meet copper's conductivity or its resistance to thermal expansion," Strong said. "If you want your system to work without worrying about reliability or interruptions then it's simple: Just use copper."

"When you look at the life-cycle assessment, generally you see an increased amount of aluminum is needed to reach the performance level that would be required from a smaller quantity of copper," she said. "Because of this reason, among others, copper is still preferred when it comes to offshore wind and underground transmission."

COPPER'S FUTURE

A recent study by Navigant indicated copper use in the wind industry will peak by 2020, but Strong said there are

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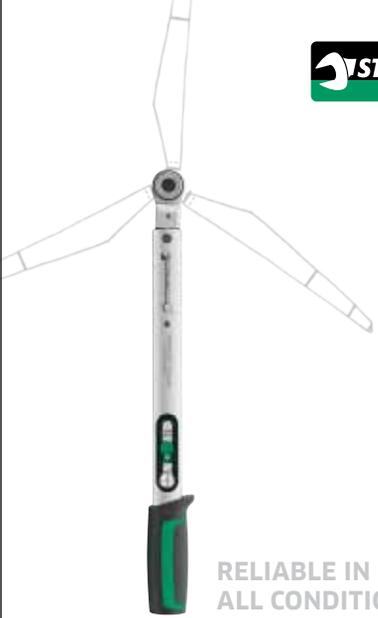
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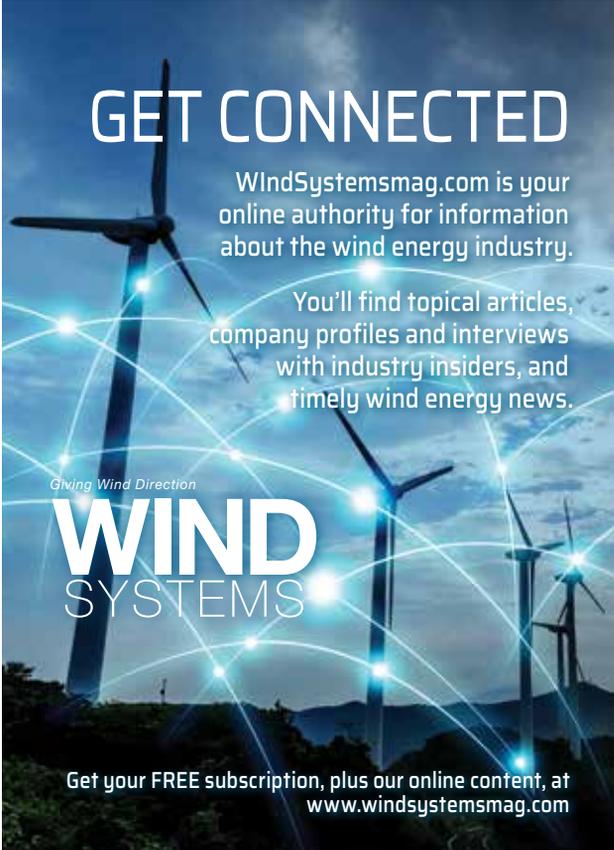
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several variables that might come into play that would affect that prediction.

“However, strides in public policy decisions and regulations will create advances in renewable portfolio standards, which may require more renewable resources,” she said.

Strong pointed to many East Coast states, such as Massachusetts, New Jersey, and Virginia, that are developing robust offshore wind plans. These initiatives will play a role in some of the projections on how many wind turbines — and therefore, how much copper — are going to be needed.

COPPER SUPPLY

With so many wind projects in the pipeline, and copper being an essential material, there is a question of the avail-

ability of copper to meet these demands. Strong said that between copper in production and copper in the scrap stream, the U.S. can meet that demand.

“The metal is infinitely recyclable,” she said. “You can reuse copper scrap that’s a hundred years old with no loss of performance. And thanks to electrical wiring in particular, the scrap stream available to us is robust.”

And with the renewable industry’s need for more copper, Strong said the Copper Development Association has a positive outlook on what the future may bring.

“The copper industry is really looking forward to seeing increased regulations and policies that help develop more offshore wind in North America,” she said. “Electricity produced offshore is dynamic and can help meet energy demands across the country.”



For both onshore and offshore wind plants, copper is a necessity for the cabling/wiring itself, but it’s also critical for handling the system’s resilience. (Courtesy: Copper Development Association)



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