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▾ THE FUTURE OF WIND



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By using advanced digital tools to not only identify underperformance, but to understand the reasons behind it, owner-operators can maximize energy production across their assets, regardless of wind resource.

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March highlights vital areas of wind

The days are getting longer, and the breeze is getting warmer as March ushers in spring (as well as daylight saving time).

At *Wind Systems*, we welcome the month of March by shining a spotlight on wind-industry staples of turbine inspection and systems and parts.

On the surface, they may not sound exciting, but they are vitally important to the life of a turbine – from its construction phase and into its daily operations.

That's why our March issue is full of interesting information about these important areas of the industry.

Starting with our inFocus section, Antonio Silverio and Anant Bhat with Schaeffler share their expertise about new high-performance main bearing solutions for wind turbines. The company's new bearing design is showing that it's able to perform under high-thrust loads.

Under the turbine inspection category, Andre Lamarre with Olympus Scientific Solutions Americas takes a close look at the inspection of composite turbine blades using ultrasonic phased array technology. This method, using low-frequency probes, can detect and size small flaws and defects such as wrinkles, delamination, disbands, and more.

In this month's Crosswinds section, Gareth Brown with Clir Renewables reveals how using advanced digital tools can help determine why turbines may be underperforming.

In Conversation, Stefan Weber with WINDSOURCING.COM discusses the importance of training seminars in an industry that can often move quickly from one innovation to the next.

And in our Company Profile, I share Pure Safety Group's story of how it offers some of the best fall prevention products and services in the industry.

You'll find all that and more in this month's issue. I hope you enjoy discovering it as much as I did preparing it to you.

As always, thanks for reading!



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Fourth quarter report reveals strong 2019

From AWEA

AWEA's recently released Fourth Quarter Market Report gives a full look at 2019 for the first time, and for fans of wind there's a lot to like. Last year was the third strongest year ever for new wind additions, and nearly 200 new wind projects are in the works. That means more reliable, affordable, clean electricity for millions of additional American families and businesses. On the whole, the U.S. now has enough installed wind to power more than 32 million homes.

Details of the report include:

- ▀ The U.S. wind industry had its fourth strongest quarter on record, installing 5,746 MW of new wind projects in the last three months of the year. This brought installations for the year to 9,143 MW.

- ▀ Fifty-five new wind farms started spinning across 19 states last year. Texas and Iowa have long been the country's wind energy leaders, and they held onto that mantle in a big way in 2019.

- ▀ Utilities and corporate customers continue to power up with wind, signing a record 8,726 MW of power purchase agreements (PPAs) in 2019. Corporate buyers accounted for 40 percent of the new PPAs signed in 2019.

- ▀ The pipeline of new wind projects under construction or in advanced development is 24 percent larger than it was at this time last year. Across 33 states, 191 different wind projects are now in the works, representing \$62 billion worth of investments.

- ▀ It was hard to keep up with all the big offshore wind announcements in 2019 – six states up and down the East Coast announced 16,300 MW of new offshore wind targets.

- ▀ Offshore wind projects now account for 17 percent of the development pipeline, totaling 7,483 MW, as more projects have been awarded contracts through state solicitations.



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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THE FUTURE OF WIND



The U.S. installed its third-largest volume of onshore wind in 2019. (Courtesy: GWEC)

Americas' wind installations rise 12% in 2019 to 13.4 GW

The latest data released by the Global Wind Energy Council (GWEC) shows North, Central, and South America and the Caribbean installed 13,427 MW capacity of onshore wind power in 2019, an increase of 12 percent on the previous year, which saw 11,892 MW installed.

In North America (Canada and the U.S.), new capacity additions grew by nearly 18 percent compared to 2018. In Central and South America and the Caribbean, new capacity additions decreased by 5 percent compared to 2018. Overall, this means that the region has tripled its wind-power installations since 2010, showing the immense progress made by wind energy as a leading power source in the Americas.

In North America, the U.S. saw an installation rush last year with nearly 10 GW installed. This was driven primarily by the Production Tax Credit (PTC) phase out and is expected to continue driving installations in 2020, while the recently approved one-year PTC extension is likely to create a new installation rush in 2024. In Central and South America and the Caribbean, strong growth has occurred in key markets such as Mexico, Argentina, and Brazil. However, the outlook for wind power in the next two to three years in some of these markets — namely Argentina and Brazil — is threatened by regulatory and political challenges.

Key insights from the data include:

- ▶ Leading countries in the region for 2019 include: U.S. (9,143 MW), Mexico (1,284 MW), Argentina (931 MW), and Brazil (745 MW)

- ▶ The U.S. installed its third largest volume of onshore wind in 2019 at 9 GW, just behind its previous records of 10 GW in 2009 and 13 GW in 2012, reaching a total of more than 105 GW.

- ▶ The offshore market in the U.S. is progressing, with first large-scale installations expected in 2022-2023 and more than 10 GW expected to be built by 2026. Brazil is also looking to tap into the offshore market and has

the potential to deploy as much as 700 GW of offshore wind, according to a roadmap for offshore wind released by the country's Energy Research Office (EPE) in January 2020.

"It is encouraging to see that installation levels for wind energy in the Americas are continuing to rise," said Ben Backwell, CEO of GWEC. "However, policymakers need to be doing more to accelerate these volumes and take advantage of the full potential wind power has to offer. Meanwhile, the ongoing trade war between the U.S. and China continues to constitute a threat for the industry, as tariffs on steel and aluminum, which make up about 90 percent of wind turbines, put price pressure on the U.S. supply chain and risk increasing wind-power projects by as much as 10 percent."

"Latin America has massive potential for wind energy, and we have seen many countries in the region emerge in recent years as renewable energy leaders through auctions, which have delivered wind energy at some of the most competitive prices globally," said Ramón Fiestas, chairman of GWEC's Latin America Committee. "New markets such as Colombia, which successfully executed its first renewable energy auction in 2019, and existing ones like Chile, which saw a record year installing 526 MW, show that there is still great untapped potential in the region. Yet, with the cancelling of planned auctions and changes to the clean-energy credits scheme in Mexico in 2019 as well as political and economic shifts in Argentina leading to uncertainty for future auctions, these key markets risk losing the momentum which they have worked so hard to create and missing out on a massive opportunity to transform their energy systems to cleaner and cheaper wind power."

These latest figures released by GWEC form the statistical release of the Global Wind Report. The Global Wind Report is GWEC's flagship publication and the industry's most widely

used source of data. The complete report provides a comprehensive snapshot of the global wind industry and an overview of trends such as the growth of offshore wind, corporate sourcing and changing business models. The full report will be released in March.

GWEC is a member-based organization that represents the entire wind-energy sector. The members of GWEC represent more than 1,500 companies, organizations, and institutions in more than 80 countries, including manufacturers, developers, component suppliers, research institutes, national wind and renewables associations, electricity providers, finance, and insurance companies.

MORE INFO gwec.net

Leading offshore conference to launch national job fair

The Business Network for Offshore Wind, a leading non-profit advocate for U.S. offshore wind at the state, federal, and global levels, will host its seventh annual International Partnership Forum (IPF) April 21-24, 2020, in Providence, Rhode Island.

New this year: the first-ever national offshore wind industry job fair plus a half-day workforce development summit, in partnership with Skills for Rhode Island's Future. The OSW CareerMatch, will showcase jobs at top-tier companies seeking to grow the workforce of the future and recruit qualified candidates. The Offshore Wind Workforce Development and Education Summit, an invitation-only event, will bring together educators, stakeholders, and industry leaders to address current training programs, identify industry employment needs, required skillsets, and how organizations can fulfill these near-term needs. CareerMatch will be



The annual IPF conference is the premier event for the offshore wind supply chain, which is now projected to be a \$70 billion revenue opportunity through 2030. (Courtesy: Business Network for Offshore Wind)

8:30 a.m. to 1 p.m. on Tuesday, April 21, and the Workforce Summit from 12:30 to 4 p.m., both at the Rhode Island Convention Center.

“The U.S. offshore wind industry has reached the stage that, in order to successfully develop and meet new project demands, will require an available and qualified workforce,” said Liz Burdock, CEO and president of the Business Network for Offshore Wind. “This first-ever national job fair will allow top-tier supply chain companies to connect with skilled individuals to discuss projects that are going on as they speak.”

“Hosting the first-of-its-kind offshore wind energy job fair in The Ocean State is apropos,” said Nina Pande, executive director of Skills for Rhode Island’s Future. “Our organization is thrilled to have the unique opportunity to help convene talent at OSW CareerMatch to engage with the employers across the offshore wind supply chain.”

The annual IPF conference is the premier event for the offshore wind supply chain, which is now projected to be a \$70 billion revenue opportunity through 2030. Fully developing this supply chain will foster local economic growth, provide thousands of jobs, and help offshore wind energy meet its potential. If fully built out worldwide, offshore wind could power 18 times the world’s current electricity needs.

The exhibit and conference sells out every year and is again on track to draw more than 2,500 industry

professionals representing more than 575 companies, all focused on sharing valuable insights on how to move the emerging U.S. wind industry forward.

MORE INFO offshorewindus.org

Pexapark offers free software version used in European PPA deals

Pexapark, a provider of software and advisory services for clean energy Power Purchase Agreements (PPA) recently announced it had launched a free version of its PexaQuote software. PexaQuote is a comprehensive solution that systemizes quotes, builds forward curves, and analyzes prices to create certainty for developers, utilities, and corporations looking to close PPA deals.

Pexapark now offers these users free access to essential tools including PexaQuote’s price indices, deal tracker, and quote service.

As subsidies across Europe are lifted, PPAs are increasingly important for developers as a strategy to manage risk in order to obtain financial security for a renewable energy project. By negotiating a PPA agreement with an agreed offtaker who will guarantee to take some, or all, of the power output at a fixed price and tenor, project owners are able to secure borrowing and investment to complete the development process. Pricing proficiency

is therefore of the essence for project owners to conduct an efficient negotiation process.

And, with an increasing number of private institutions joining utilities in committing to obtaining power sourced from clean technologies, buyers need a mechanism by which to navigate some of the complexity of pricing and contract negotiation. This is critical during a procurement process that can be unfamiliar and where a significant investment in time and staffing may be required to collect and analyze market data to determine the best price and structure for a PPA.

Pexapark’s software, data, and advisory services have been developed to create certainty for buyers and sellers as clean energy transitions away from subsidies and toward an open market.

Since 2019, the business has used insights from its software and database to support more than 50 PPA deals struck in Europe. Pexapark developed PexaQuote in 2019 to analyze power price data and provide a quote based on real-time energy valuation and the specifics of a given project.

PexaQuote’s free edition includes price indices by market and a PPA deal tracker, which records deals closed in the EU as and when they are disclosed. The software allows users to analyze the volume of deals across different technologies and countries. In addition to providing insight into pricing across the market, the free version also includes a new feature wherein the user is able to request a quote for a given PPA structure. If any sell side parties are interested, the software automatically matches them to the user.

“The future of renewable energy is subsidy-free,” said Luca Pedretti, Pexapark’s COO. “However, given the renewable PPA market is still relatively new, many businesses interested in either selling or buying clean energy do not have access to the data needed to determine price or structure. And even when they have access to the data, it can take weeks for a team to analyze it and come to a final quote. PexaQuote allows both sides of the PPA transaction to identify the best structure and

price for a given deal in a matter of seconds.”

“By providing a free level of access to our proprietary software, we’re enabling the wider market to be able to take advantage of data availability that has been critical to driving European PPAs to date,” Pedretti said. “This is a core part of our objective to drive forward the transition in clean energy to a merchant market.”

MORE INFO www.pexapark.com

Siemens ups stake to 67.1% to spin-off SGRE into Siemens Energy

Siemens has bought out Iberdrola’s 8.1 percent stake in Siemens Gamesa Renewable Energy (SGRE) for a total cost of \$1.2 billion, potentially ending a period of acrimony between the two companies and bringing a major customer back into SGRE’s fold. This price is equivalent to 20 euros/share – a 32 percent premium on top of SGRE’s average share price for the last 30 trading days.

Gamesa will now own a 32.9 percent stake in SGRE, with Siemens holding the majority 67.1 percent stake in the company. In addition, Iberdrola, as a customer of Siemens Gamesa and Siemens, signed a cooperation agreement that will grant exclusive negotiation rights, for a limited period of time, for certain wind-power projects and for improving the distribution grid. Siemens expects that additional annual savings of up to 900 million euros in net present can be realized for SGRE through intensified cooperation between Siemens and SGRE and an additional 100 million euros annual savings by “unwinding the shareholder agreement.”

The divestment is part of the company’s asset rotation strategy. Siemens will transfer its majority stake in SGRE to its gas and power business, Siemens Energy, as part of its planned spin-off and subsequent public listing. The pure-play energy business aims to be the “go-to institution for combating

climate change” with the scale to win in wind.

“Siemens targets to co-fire its gas turbines with 20 percent hydrogen in 2020 and 100 percent hydrogen by 2030; and its commitment toward the Paris climate targets is being hit by plunging demand as the global power sector looks to decarbonize its operations,” said Bhavana Sri Pullagura, power analyst at GlobalData. “In

this connection, a robust, profitable, and innovative business is a key prerequisite for success. Siemens Energy will have the scale needed to succeed in terms of innovation, resources and geographical reach in key renewables markets such as the wind power sector which will help to shape the energy transition.”

MORE INFO www.globaldata.com

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A close-up, low-angle shot of a white wind turbine nacelle against a clear blue sky. The image focuses on the main bearing area, showing the circular structure with multiple bolts and a black cable. The perspective is from below, looking up at the turbine.



A new bearing design is able to perform under high-thrust loads while still maintaining its excellent misalignment characteristics.

By ANTONIO SILVERIO and ANANT BHAT

Today's modern wind turbines can produce more than 7 MW of electrical power per unit – with offshore prototypes capable of achieving an output of as much as 12 MW – making these majestic machines an indispensable source of energy to help mitigate the detrimental effects of climate change.

Consequently, ensuring that wind turbines operate reliably with minimal downtime is vitally important – not just for the environment, but also for wind-farm operators, utilities, and their customers. One area of opportunity for improving wind-turbine reliability involves the rotor shaft bearing support, a vital component inside the turbine's nacelle where the bearing is subjected to particularly high loads.

In response to increasing incidents of failed bearings in the field, global industrial and automotive supplier Schaeffler began an investigation into the causes of these main bearing failures. In addition to generating significant improvements to currently used bearing solutions, Schaeffler's research resulted in a new spherical roller bearing design for wind-turbine main shaft applications that offers high wear resistance as well as considerably lower friction torque and operating temperatures than the conventional standard. As such, this innovation has the potential to significantly extend the turbine's operating life.

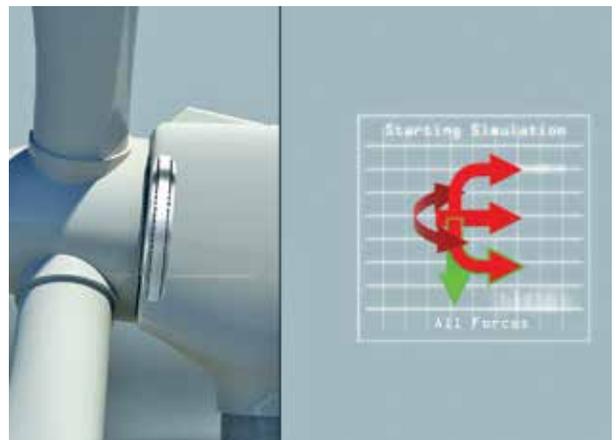


Figure 1: Rotor shaft bearings are subjected to a range of dynamic loads, especially high axial loads.

RECOGNIZING AN OPPORTUNITY FOR IMPROVEMENT

Inside a wind turbine, the main shaft supports the main rotor hub and transmits rotational energy in the form of torque from the rotor hub to the gearbox. This application requires high reliability as well as robust resistance to the high loads generated by the rotor blades. Due to the high levels of thrust generated in this environment (see Figure 1), conventional double-row symmetrical spherical roller mainshaft support bearings used in wind turbines experience uneven internal load distribution between the roller rows. This causes the rotor-side row to have lower load, while the gearbox-side row is potentially overloaded. Because of the low speed of the rotor shaft, only a minimal grease lubrication film is generated. This, in turn, produces a metal-to-metal running condition. The result: a high rate of surface wear, poor performance, and, ultimately, premature bearing failure.

As part of Schaeffler's extensive investigation of failed bearings — which was based on data obtained by analyzing the performance of approximately 10,000 wind turbines throughout the world — it was noted that a significant percentage of failures occurred mostly in bearings used in 3-point support rotor shaft systems. This shaft system is fitted with standard spherical roller bearings designs that feature two rows of symmetrical barrel rollers. Most of the damage was found to be concentrated internally on the axially loaded row (downwind) of the locating bearings. The damage, observed primarily at the surface level, is classified in accordance with ISO15243 as either fatigue occurring near the surface (also known as surface distress) or abrasive wear.

As mentioned earlier, abrasive wear in wind turbine main bearings operating under random conditions is primarily caused by varying shaft speed and loads that can lead to a very thin or nonexistent lubricating film. If the separating lubricant film between the roller and raceways surfaces is allowed to degrade, micropitting, smearing, and, eventually, extensive damage (spalling) at surface levels will be the result (see Figure 2).

OPTIMIZING THE EXISTING STANDARD

In order to offer customers a choice of solutions that would best meet their objectives and budget requirements, Schaeffler began by looking at optimizing the performance and service life of standard spherical roller bearings currently used in this application.

The first step was to develop and validate a lubricant formulated with the proper load-carrying properties for a variety of operating conditions, including low shaft speeds and extreme loads. Beyond merely improving the lubrication conditions, however, a strong emphasis was placed on optimizing the bearing design with enhancements such as extremely strict surface finish limits and special coatings on the rollers.

To that end, Schaeffler optimized the standard bearing design by applying the company's proprietary Triondur® C coating to the rollers. Triondur C is a metal-containing hydrogenous amorphous carbon coating that offers a high level



Figure 2: Spalling on the gear-box side of a wind turbine main shaft bearing: the result of uneven load conditions.

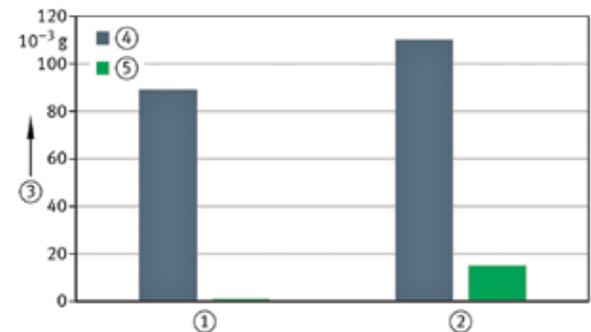


Figure 3: Comparing wear on uncoated vs. Triondur C-coated rolling elements.

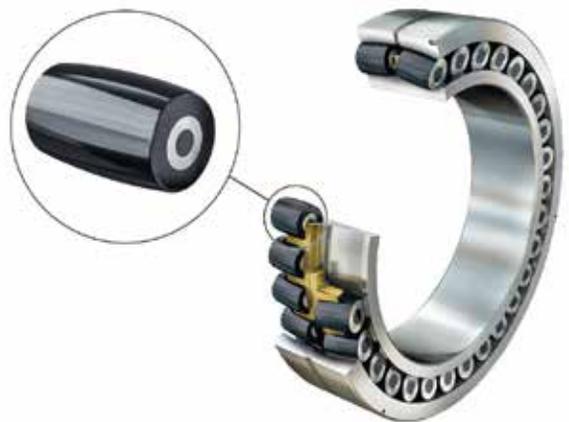


Figure 4: Bearing rolling element with Triondur C coating.

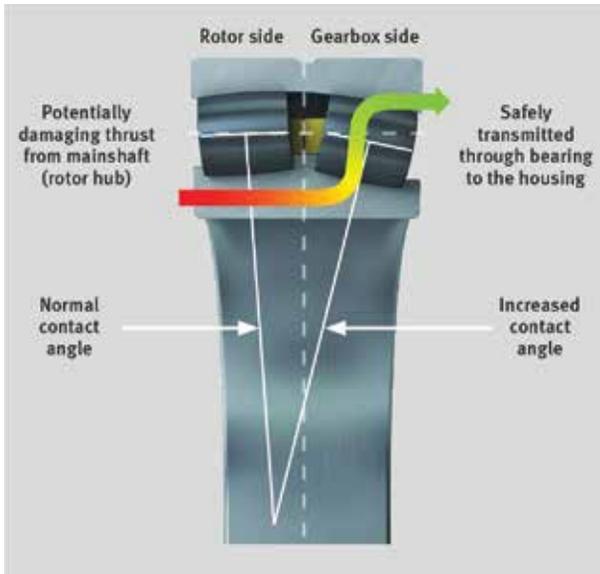


Figure 5: Cross section of asymmetric spherical roller bearing showing load being transferred through bearing.

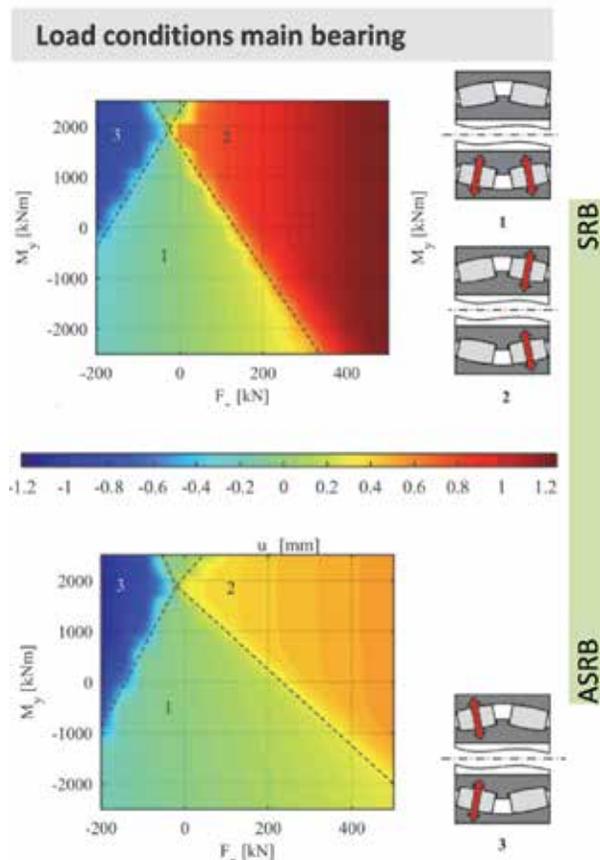


Figure 6: Graphs showing test results of load conditions in a conventional spherical roller bearing (SRB) and Schaeffler's asymmetric spherical roller bearing (ASRB).

▀ Innovations such as the asymmetric spherical roller bearing are designed to offer reduced maintenance costs and increased wind-turbine availability. In other words: greater productivity and profitability for wind farm operators. ▀

of protection against abrasive and adhesive wear (see Figure 3). Due to its highly ductile coating structure, Triondur C can withstand the high contact pressures that routinely occur in rolling bearing applications. As a result, rollers finished with Triondur C (see Figure 4) significantly reduce sliding friction and minimize sliding-induced damage. To further mitigate the potential for sliding, Schaeffler's upgraded bearings use a two-piece brass cage that enables each roller row to rotate independently.

Other enhancements to the standard spherical roller bearing design included:

- ▀ Improving the quality of the internal components' surface finish.
- ▀ Optimizing the osculation (i.e. the roller-to-race conformity) in order to obtain the lowest contact pressures.
- ▀ Using rollers with logarithmic profiling to reduce surface damage in the most critical contact areas.
- ▀ Optimizing the internal clearance to both reduce the rotor shaft displacement under heavy thrust loads as well as improve the load-per-roller distribution.
- ▀ Adding a central rib to the inner ring in order to increase axial rigidity as well as improve contact pressure distribution throughout all rollers to reduce surface damage.

In addition to optimizing the bearing itself, Schaeffler also looked at how the bearing replacement process could be made more efficient and economical. This analysis included considering the shaft on which the bearing is mounted. Due to the heavy fretting corrosion and material attrition that occurs during normal operation, many of these shafts require a reworked mounting surface – a complex and expensive process that involves removing the damaged layer and replating the shaft's outer diameter to return it to its original dimension. Not surprisingly, having to rework a shaft typically adds to the wind turbine's downtime. Schaeffler's solution: Save money and time by using a bearing with an undersized bore, thereby eliminating the need to rebuild the shaft altogether.

ENGINEERING A DESIGN BREAKTHROUGH

Beyond merely optimizing the conventional bearing design used in most wind turbines, however, Schaeffler was determined to provide the ultimate bearing solution that would be able to perform under high-thrust loads while still maintaining its excellent misalignment characteristics. To that end, Schaeffler developed and patented a new bear-

ing design for main shaft bearings in wind turbines: the asymmetric spherical roller bearing. The term “asymmetric” refers to the bearing’s different contact angles, which serve to improve the load distribution between both bearing rows, reduce the contact pressure and friction torque, and increase axial stiffness by approximately 50 percent. Moreover, the bearing’s unique design prevents roller-to-raceway contact stress peaks from developing as a result of the periodic bending of the rotor shaft during operation or accuracy errors that arise from the initial assembly inside the wind turbine’s nacelle.

The operating principle behind Schaeffler’s asymmetric spherical roller bearing is as follows: While the rotor side of the bearing is designed to carry the normal radial load present in the application, the gearbox side of the bearing is optimized with an increased contact angle to accommodate the high thrust. During operation, the potentially damaging thrust is safely transferred through the bearing and transmitted to the housing support (see Figure 5). The innovative asymmetric design ensures a more even internal load distribution, which provides improved rolling motion while minimizing sliding. The result: less torque, less friction, and less heat. Plus, the axial displacement of the bearing is also reduced. Bottom line: The overall efficiency of the system is improved, which allows the wind turbine to generate more power.

VALIDATING THE BENEFITS THROUGH RIGOROUS TESTING

To validate these claimed performance improvements, a comparison test was performed at Germany’s University of Aachen in which a standard, commonly used 240/710-size spherical roller bearing was pitted against Schaeffler’s new asymmetric design. The bearings were tested by simulating real-life conditions inside a test rig fitted with 232 sensors placed in strategic locations throughout the nacelle to monitor all operating conditions such as main bearing loads, acceleration, and deflections as well as potential adverse impacts of excessive axial displacements.

The test results revealed that Schaeffler’s asymmetric design provides better load distribution between both roller rows under a combination of axial and moment loads. In Figure 6, the region in the graph marked “1,” which represents loads distributed between both roller rows, is considerably larger for the asymmetric design (bottom graph) than for its conventional counterpart (top graph). Similarly, a standard spherical roller bearing exhibits considerably more axial displacement as shown by the top graph’s darker red color in the region marked “2,” which represents the loads applied only to the downwind roller row.

OFFERING SOLUTIONS THAT SERVE BUSINESS AS WELL AS ENVIRONMENTAL INTERESTS

Schaeffler works with its partners in the wind industry to develop the optimum solutions for every bearing position inside the wind turbine — from the rotor shaft to the gearbox to the generator to the nacelle to the blade adjustment system. A comprehensive selection of special rolling bearing greases and a wide range of services and products for maintenance and condition monitoring round out Schaeffler’s portfolio of offerings to the wind industry.

Innovations such as the asymmetric spherical roller bearing are designed to offer reduced maintenance costs and increased wind-turbine availability. In other words: greater productivity and profitability for wind farm operators — and plenty of clean, reliable power to help combat climate change. ↵

ABOUT THE AUTHORS

Antonio Silverio and Anant Bhat are with Schaeffler Group USA Inc. With over 35 years of experience in bearing applications engineering, Silverio has been Schaeffler’s technical lead for wind industry applications in the U.S. since 2002. In this role, he works with Schaeffler’s customers to develop and supply bearing solutions that improve wind turbine efficiency and reliability. Silverio holds a BSME from the University of Bridgeport, Connecticut. Bhat leads the engineering teams for Schaeffler’s Renewable Energy and Railway activities in North America. To that end, he is able to draw upon over a decade of experience in bearing production, engineering, key account management, and business development. Bhat holds a bachelor’s degree in mechanical engineering from the University of Bengaluru, India, and an MBA from the University of Applied Sciences in Nuremberg, Germany.



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INSPECTION OF COMPOSITE TURBINE BLADES WITH ULTRASONIC PHASED ARRAY TECHNOLOGY

Ultrasonic phased array can be used to inspect wind blades with low-frequency probes to detect and size small flaws and defects such as wrinkles, delamination, disbonds, and more.

By **ANDRÉ LAMARRE**

1 INTRODUCTION

In-service wind turbines operate in harsh environments. While the wind blades are subjected to a high-level of stress, other components of wind turbines are also exposed to difficult conditions. To help ensure the integrity of wind turbines when in-service, it is important to apply efficient and reliable nondestructive testing methods. This paper focuses on the inspection of composite wind blades using ultrasonic phased array.

2 MAIN COMPONENTS OF A WIND TURBINE

A wind turbine is made up of four main components. While the rotating wind-turbine blades generate the aerodynamic torque, the nacelle converts the torque into electrical power. The tower supports the nacelle and rotor blades and provides access to the nacelle. The foundation ensures that the turbine remains upright.

Nondestructive testing helps to ensure the integrity of these components during manufacturing, construction, and maintenance of the wind turbine.

2.1 A turbine blade dissected

A turbine blade is composed of an outer shell reinforced by one or many internal structural beams called spars. The number of spars depends on the size of the blade. The interior of the blade is hollow. Depending on the manufacturer, the spar could be an I-beam or a box. The I-beam spar is composed of two spar caps and one shear web, while the box spar is composed of two spar caps and two shear webs. In both cases, the spar caps are attached to the skin with adhesive.

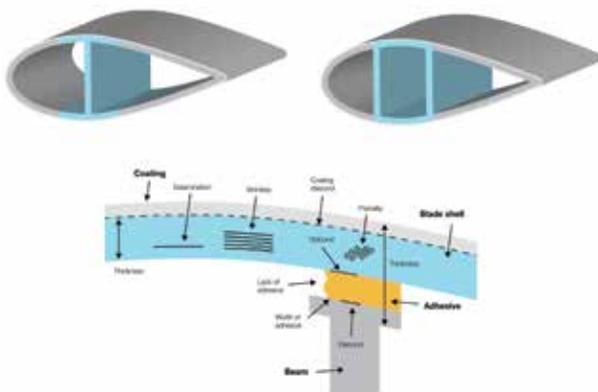


Figure 1: I-beam spar (top left) and box spar (top right); types of flaws in a composite turbine blade (bottom).

A turbine blade is composed of different materials, including glass-reinforced plastic (GRP) fiber, carbon-reinforced plastic (CRP) fiber, balsam/wood, adhesive, resins, honeycomb structures, and coatings. Most of these materials are not qualified as acoustic friendly.

2.2 Types of flaws

Composite turbine blades are prone to flaws that can be the result of the blade's design or the manufacturing process. These flaws include porosity, disbonds, delamination, inclusions, and wrinkles (out-of-plane waviness). It is important to not only identify and size these flaws but also characterize the width of the adhesive and its position between the beam and shell.

3 PRINCIPLES OF OPERATION OF PHASED ARRAY TECHNOLOGY

Phased array technology is based on the capacity to electronically modify ultrasonic beams generated by a phased array probe that contains multiple small elements. When these elements are excited with different time delays (focal laws), the beams can be steered at different angles, focused at different depths, or multiplexed over the length of a long array, creating an electronic movement of the beam.

Multiplexing, sometimes called an electronic or linear scan, is used to perform wind-blade inspection. The sensor consists of a phased array probe that is 25-100 mm (1-4 in.) long and contains between 32 and 128 elements. A small group of elements, defined as the active aperture, is activated to generate an ultrasonic beam propagating normal to the interface. This group of elements is then indexed using electronic multiplexing, creating a true physical movement of the ultrasonic beam under the array with an index as small as 1 millimeter. The electronic indexing is performed so fast that a 100-mm (4-in.) line length is covered by the ultrasonic beams in milliseconds.

3.1 Olympus equipment for composite wind-blade inspection

3.1.1 Phased array probes

The Olympus sensors used for composite wind-turbine blades are low-frequency phased array probes with the following characteristics: the frequencies available are 0.5 and 1 MHz, and they have 64 elements. The length of the array is 96 mm with a pitch of 1.5 mm, and the elevation is 22 mm. Plastic housing is used to reduce the weight. The sensors



Figure 2: Low-frequency phased array probe (top left) and probe holder (top right); Olympus phased array instruments for wind blade inspection (bottom).

are mounted on different probe holders. One is a semi-contact probe holder used for deep penetration, while the other is equipped with a delay line, resulting in an improved near-surface resolution. Both probes holders are available in either a curved or flat configuration. Each probe holder has water irrigation and an encoder attachment.

3.1.2 Ultrasonic phased array equipment

Olympus offers a variety of ultrasonic phased array equipment for the inspection of composite wind blades. The portable single PA probe-compatible OmniScan® SX ultrasonic flaw detector and the multiprobe-compatible OmniScan MX2 multitechnology flaw detector can be used for manual and semiautomated inspection. The FOCUS PX™ PC-based phased array and ultrasonic data acquisition unit and the OmniScan MX2 can be used for semi- and fully-automated inspection.

4 DETECTION CAPABILITIES OF ULTRASONIC PHASED ARRAY

4.1 Spar inspection

The box spar of a composite wind turbine was inspected with a fully automated scanner mounted on suction cups. The results are observed on a C-scan that represents the mapping of the inspected area. At CRP or GRP flanges, the ultrasound reflects off the inner side of the skin, resulting in a strong echo (represented in red on the C-scan). At bonded zones, if the bond is good, the ultrasound travels through the adhesive and disperses into the web, resulting in missing or weak

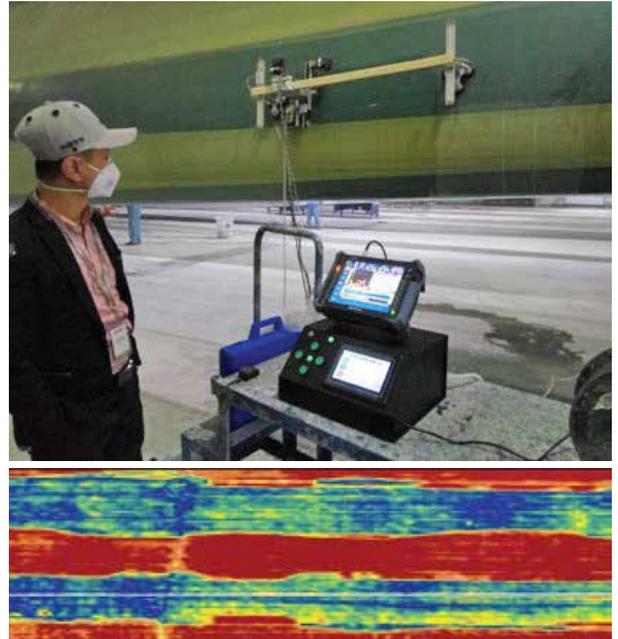


Figure 3: Spar inspection configuration (top) and spar inspection C-scan results (bottom).

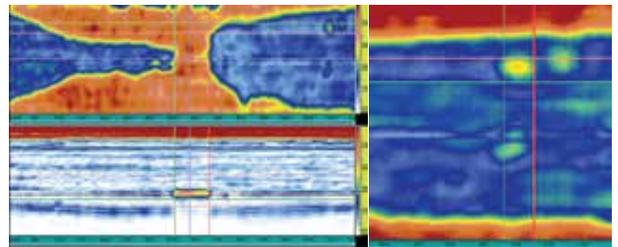


Figure 4: C-scan (top of left screen), B-scan (bottom of left screen), and zoomed view (right).

echoes at the bonded interface (represented in blue or yellow on the C-scan). In Figure 3, the width of the adhesive zones can be measured, and local deficiencies can be located in the bonded area with a sizing resolution of 1.5 mm.

4.2 Bonding evaluation

A composite wind turbine with deficient bonded zones was inspected with the same inspection configuration as previously described, and the results are shown on the C-scan in Figure 4. Observe that the width of the bonded zone gradually narrows up to an 80 mm long section that is completely disbonded. Localized unbonded areas measuring approximately 20 mm x 20 mm are also present in the good area.

4.3 Delamination

Delamination between glass-reinforced plastic (GRP) and carbon-reinforced plastic (CRP) layers can be easily located using phased array, as these materials are good ultrasound

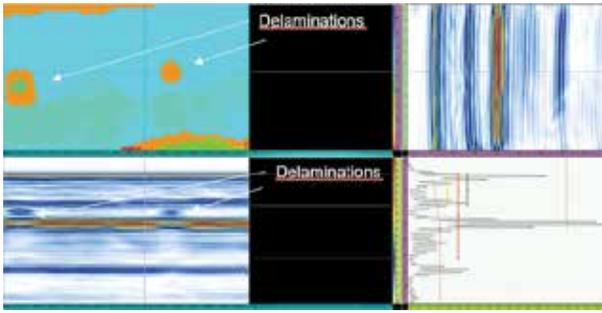


Figure 5: C-scan TOF (top left), B-scan (bottom left), D-scan (top right), and A-scan (bottom right).

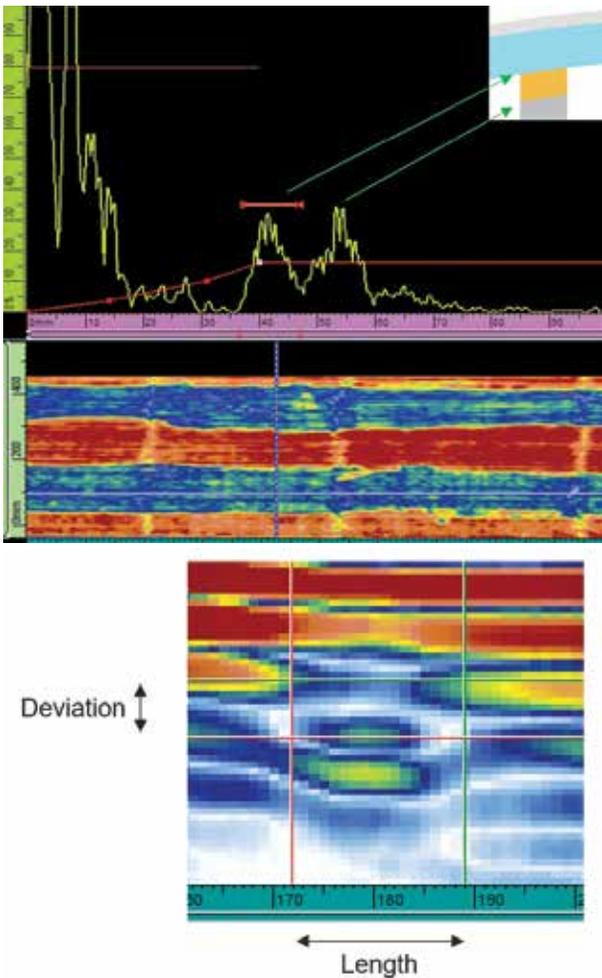


Figure 6: Bonding thickness measurement (top) and wrinkle ultrasonic evaluation (bottom).

reflectors. Nevertheless, a time-of-flight (TOF) C-scan is a useful tool to discriminate between geometric echoes and delamination as illustrated in Figure 5.

4.4 Adhesive thickness measurement

Depending on the adhesive material, echoes from the in-

terface of the shell's glue and the web's glue are visible. The distance between these two echoes characterizes the adhesive thickness. Using the appropriate velocity, the adhesive thickness can be evaluated.

4.5 Detection and sizing wrinkles

A wrinkle is an out-of-plane alignment of the composite layer of a wind blade. Wrinkles reduce the blade's tensile strength and can create out-of-plane delamination. When the right probe frequency is used, it is possible to evaluate the length and deviation of a wrinkle as illustrated below.

5 ULTRASONIC PHASED ARRAY INSPECTION PRODUCTIVITY

Ultrasonic phased array inspection of a wind blade can be performed in different ways. It can be operated manually with or without an encoder, and it can also be operated in a semi or fully automated manner.

The example configuration presented in Figure 3 is a fully automated system using a two-axis motorized scanner with suction cups holding it to the wind blade. The scanner covers 5 meters in the span direction and 0.5 meters in the chord direction. The OmniScan[®] MX2 multitechnology flaw detector performs the data acquisition, driving a low-frequency phased array probe. The probe can scan either in the chord or span direction. With this configuration, using an acquisition resolution of 1.5 mm on both axes, the inspection rate is 3 square meters per minute while recording A-scan and C-scan data.

6 CONCLUSION

Ultrasonic phased array can be used to inspect wind blades with low-frequency probes (0.5 and 1 MHz). The 1.5 mm resolution enables the detection and accurate sizing of small flaws. Defects such as wrinkles, delamination, and disbonds can be detected and sized. Adhesive thickness measurement can also be performed. Ultrasonic phased array technology enables fast inspection while maintaining 100 percent coverage of the part. Off-the-shelf phased array units can be used in a stand-alone configuration or integrated with automated scanners. While C-scan imaging enables analysis at a glance, the use of A B C D images permits a more detailed interpretation. The use of ultrasonic phased array can also be considered for wind-turbine blade maintenance programs. ✎

ABOUT THE AUTHOR

André Lamarre is a graduate in engineering physics and holds a master's degree in materials science. He has accumulated more than 20 years of experience in phased array ultrasonics. Lamarre is now the acting business development manager for the power generation and aerospace industries at Olympus Scientific Solutions Americas. Contact him at andre.lamarre@olympus-ossa.com. This article was originally published in the 12th European Conference of Non-Destructive Testing in Gothenburg, Sweden, June 11 - 15, 2018. Reprinted with permission.



PROFILE

PURE SAFETY GROUP

PROTECTING WORKERS AT HEIGHT

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Not only does PSG design and manufacture its fall protection equipment, it makes sure technicians get the proper fall protection training. (Courtesy: Pure Safety Group)

Pure Safety Group is the largest independent manufacturer focused solely on fall protection, created to service the broadest range of individuals working at height.

By KENNETH CARTER ▸ Wind Systems editor

Anytime a technician must operate high above the ground, fall protection becomes a paramount concern.

That fall protection covers several aspects: both the safety of the worker, as well as the equipment.

Pure Safety Group (PSG) has been offering products and services designed to ensure both workers and equipment are secure in many industries, particularly wind.

“Wind is one of the core segments of fall protection that we are focused on,” said Judd Perner, director of Marketing and Product Management at PSG. “Our goal is to continue providing innovative solutions that can be used to protect workers at height and equipment in wind-turbine environments. Most technicians and professionals working in the wind industry are at height from time to time, and we take their specific environmental situations very seriously.”

WIDE RANGE OF PRODUCTS

PSG offers a range of products specifically designed for wind, ranging from full-body harnesses, lanyards used for climbing structures, and personal and overhead self-retracting lifelines, according to Perner.

“Those are the primary product categories of this segment,” he said. “We also have a range of rescue and controlled descent devices such as the Checkmate Max 150. If there’s an issue at the top of a wind turbine and they have to get down quickly, they can connect to the descender, and it’ll lower them to the ground safely at a controlled rate.”

PSG began with a group of industry experts, with more than 100 years of collective experience, who analyzed the industry and identified a need for a single organization focused on the vital aspect of working at height, according to Perner.

THREE CORE BRANDS

“The first acquisition was Guardian Fall Protection,” he said. “Guardian had been in the industry since the early ’90s and is a well-established brand serving multiple industries. In 2017, PSG also acquired Web Devices, which was a regional fall protection company out of Houston, Texas. By taking those two companies and merging them together, we were able to really develop ourselves as a large provider of fall protection equipment. And that’s what led to our global headquarters in Houston, Texas.”

In 2018, PSG acquired Checkmate and Ty-Flot, according to Perner. Checkmate was a U.K.-based fall protection company specializing in high-performance, innovative, and technology-based safety products. Ty-Flot was a company

that focused on foreign material exclusion and dropped-object prevention products that allowed workers at height to tether different types of tools. “The Ty-Flot business originated in the nuclear industry, where it was really important to ensure that tools and equipment — if they were dropped — weren’t going to fall and damage equipment, in addition to the safety hazards associated with dropped objects,” he said.

As PSG, a family of three strong fall protection brands have been established, according to Perner.

“Each brand highlights and fulfills an industry need; Guardian-branded products serve professionals seeking quality products meeting and exceeding compliance standards, while the Checkmate brand is well established with those seeking high-performance products that are able to endure challenging environments such as those in the wind industry and Stronghold by PSG which is a brand that offers a range of products that is able to cross both the high performance and compliance product offerings,” he said. “Stronghold products are important to the wind-energy segment of fall protection because it allows workers to not only protect workers working below them, but also the equipment that they’re working on. Our focus is to utilize the full range of product offerings between the family of brands to create unique solutions for end users in all environments.”

SOLVING CUSTOMER CHALLENGES

With the importance of fall protection, Perner pointed out that PSG takes every challenge a customer brings very seriously. “We welcome challenges, and we see all challenges as an opportunity to help customers solve a problem,” he said. “We have a very talented team of engineers, project managers, and certified installers that makes up Engineering Systems that is able to work with end users on specific work site challenges and design thoughtful solutions.”

Being able to partner with end users provides PSG’s engineers with valuable field feedback that can lend to new product innovations or added features in existing products, according to Perner.

“We believe that the people working at height day in and day out are the individuals who can best explain what obstacles or challenges they face,” he said. “If they can bring that to an equipment manufacturer like Pure Safety Group, we can take that information and work with our engineering teams to develop a solution that they can then use to protect themselves.”

PROPER TRAINING

Not only does PSG design and manufacture its fall protec-



tion equipment, it makes sure technicians get the proper fall protection training, according to Perner.

“We opened our fall-protection training facility at our Houston headquarters in 2018,” he said. “That training facility has several structures that simulate different conditions, such as confined space. We offer a variety of training courses that incorporate both classroom and hands-on training. Opening the Houston training facility was a significant achievement for PSG. It established us within the Houston community and our investment in training and education. Proper education is equally as important to the products themselves, because if you don’t know how to use the product and don’t know the standards, that can become a critical issue on job sites. We have placed considerable emphasis on creating a robust training curriculum for our trainers to provide not only within our training facilities, but also remotely and online for convenience learning.”

CONSTANTLY IMPROVING

As the wind industry continues to evolve, Perner stressed that PSG’s product management and engineering teams continue to look for new and innovative ways to improve the equipment it offers to wind industry.

“We’re evolving with the industry mainly through material and technological advancement as well as engineered system solutions,” he said. “Our approach to evolving product offerings is to be in the field as much as possible, gather valuable feedback from individuals who use these products daily and engage them in the development of the solution or advancement to make sure it’s feasible.”

The wind industry has some unique challenges: on vs. off shore, confined space, environmental, etc., so Perner said PSG continues to research materials such as high-performance ropes

Being able to offer high-performance materials integrated with industry specific designs and training will continue to distinguish PSG and its brands. (Courtesy: Pure Safety Group)

and webbings that are heat-resistant for products such as rescue equipment to ensure a controlled descent. Being able to offer high-performance materials integrated with industry specific designs and training will continue to distinguish PSG and its brands.

“Every industry has its own challenges,” he said. “And if you look at wind, a wind-energy technician might require specialty features on their products, whether it’s a lanyard capable of foot level tie-off or descender for escape situations. The technicians need specific features to make their job safer. We’re going to continue focusing on developing products that are unique to wind, just like we are striving to do for all of the other industries that we serve. Whether it is general industry, construction, wind energy, or utilities, we are always focusing on making sure that if a particular industry has an application or a hazard that is specific, then we will provide a solution for that specific application.”

OFFSHORE APPLICATIONS

As wind energy expands more offshore, PSG will expand its innovative solutions specific to this environment, according to Perner.

“Products in this environment are exposed to the harshest of conditions, so we look to incorporate materials such as stainless steel to reduce corrosion from saltwater and humidity,” he said. “Having our own certified testing facility gives us the ability to thoroughly test more of these alternative products with environmental controls to see how they perform to drive designs forward. Looking for high performance materials and design solutions that meet global compliance standards across are the primary goal of the product development team.”

“We believe that by focusing solely on fall protection we can become the experts and strive to continually push the envelope developing products and training,” Perner said. ✎

As wind energy expands more offshore, PSG will expand its innovative solutions specific to this environment. (Courtesy: Pure Safety Group)





Stefan Weber

Founder and Managing Director ▶ WINDSOURCING.COM

“With this exchange of information and getting familiar with the application, it can make things much easier onsite, and that is a reason why trainings like this are so important.”

Recently, WINDSOURCING.COM GmbH and Sika Deutschland GmbH offered a free product training seminar for wind-industry customers that covered the use of SikaCor® SW-1000 RepaCor for the professional repair of corrosion protection of onshore and offshore wind turbines and hydraulic steel structures. *Wind Systems* talked with Stefan Weber, WINDSOURCING.COM’s founder and managing director, about the benefits of training seminars such as this one.

▶ What is your background in the wind industry?

My background in the wind industry is that I previously worked for a very ambitious renewable energy company here in Germany that was involved in all aspects of renewable energies such as PV, wind, bio-gas, and solar thermal power plants. And I was responsible for different purchasing activities in these fields, particularly wind-purchasing activities.

▶ What is SikaCor® SW-1000 RepaCor, and why is it important to the wind industry?

When you need to do a corrosion repair job offshore or, let’s say, at the turbine, the normal procedure in the past was that you needed to apply all three layers separately from which the corrosion protection was made of. With SikaCor SW-1000 RepaCor, you have to go to the area that you want to repair only once, and apply it to the surface, and then you are done. And that is a very big improvement for the wind industry, because, especially in the offshore business, it can be a real nightmare to go three times to the same turbine, to the same area, to apply a different layer of corrosion material. That is very cost-intensive even though you just have to wait four or five hours for the first layer or the second layer to dry. You need to go back and forth, back and forth. And with this material, you only need to go there once, prepare

the surface according to the Sika repair standards, then you apply the material, and then it’s done. You have the corrosion protection again at this area.

So that is really a no-brainer for many of our customers here in Europe and the offshore business because it really saves a lot of time — and of course, money — doing smaller repairs onsite.

▶ WINDSOURCING.COM sponsored the recent training seminar using SikaCor SW-1000 RepaCor. Who benefited from the training course?

Anybody who was using the material in the field can benefit. And for somebody who didn’t know the product well, everybody who is doing repair jobs in the corrosion area of wind turbines or fundamentals or offshore parks could try this material and really use it during our training and get familiar with it. And the Sika experts were there as well, so if somebody wanted to discuss very deep technical questions, it wasn’t a problem because the colleagues were there to answer all the questions that came up.

▶ What else made this training course unique?

You had a concentrated theoretical part for one and a half hours where a technician who was involved in the development of this new product gave insights of the development of the materials along with some background information about the technical application and what the product really can do. And after this theoretical part, you could really start using the material during the training and get familiar with it. I think this was a very good combination.

▶ So, it had a hands-on element to it?

Yeah. Of course, the hands-on element was very important. This was the third year we have done this training. The



Part of what made the SikaCor® SW-1000 RepaCor training seminar useful was the ability to have a hands-on learning experience. (Courtesy: WINDSOURCING.COM)

most interesting part for most of the participants was the usage of the material.

► **Why do you think product training like this is important?**

I think it's important because there are so many new developments in every aspect of the market, and it's very important for the guys who really use the product at the end of the day, onsite, that they have a safe environment where they can really use the material and get familiar with it. That makes life onsite much easier for everybody if he or she has already used the material and was able to talk to people who have developed it. I think, especially with this exchange of information and getting familiar with the application, it can make things much easier onsite, and that is a reason why trainings like this are so important.

► **Why should special product training courses like this**

one be made available to the industry on a regular basis?

The wind after-sales market and the service market are growing so fast, and there are so many new guys constantly coming into the market, so many new employees, that it is necessary to offer this regularly in order to give newcomers and new people the possibility to get familiar with the products that are available.

► **Are you planning on doing more seminars like this one?**

We are planning other training courses. We just had a training course in January with 3M. That is also one of our supply partners. We are planning at least one or two other training courses with other suppliers this year, but nothing is finalized yet. With Sika, although we won't be doing another one this year, there will be another date at the beginning of next year. ↵

MORE INFO www.windsourcing.com



The Bachmann team in Rendsburg will aid in retrofits to extend turbine lifetimes. (Courtesy: Bachmann)

MAINTENANCE

Bachmann expands its retrofit capabilities with team acquisition

Bachmann electronic, an industry leader in wind automation solutions, recently strengthened its significant expertise by acquiring a team of 10 wind-energy experts.

With more than 20 years' experience in turbine control technology, the new team in Rendsburg/Büdel-dorf, Germany, will concentrate on the global turbine retrofit market. Their target is to provide turbine Life Time Extension (LTE), optimized efficiency, and support wind farms in delivering affordable energy.

Bachmann retrofitted turbines are

now compliant with advancing technical requirements with increased cyber security and optimized operator safety. The Bachmann M1 automation system offers a wide variety of software components to older turbines. Components such as WTT (Wind Turbine Template), WPS (Wind Power SCADA), SPPC (Smart Power Plant Controller), Condition Monitoring Systems (CMS), and Structural Health Monitoring (SHM) update and standardize technology to meet international standards. Bachmann wind-energy customers increase their farm's efficiency, lower costs, and maximize performance.

"We are very excited to be joining Bachmann," said Martin von Mutius, head of the new retrofit team. "We want to grant independence to our customers, giving them the most

from their turbines. This means durable, long-lasting automation solutions ensuring continuous productivity throughout turbine lifetimes; exactly what Bachmann provides."

Bachmann electronic, a global automation company with headquarters based in Feldkirch, Austria, has been optimizing customer productivity and profit for 50 years. With more than 20 years' experience in the wind market and as the leader in wind-energy automation, Bachmann provides the highest quality, durability, and reliability to one in three turbines worldwide.

Open and flexible communication standards, integrated machine health monitoring and web-based visualization are just part of the total solution Bachmann offers its customers. Continuous innovation and accumulated engineering know-how safeguard suc-

cess and build trusted partnerships between Bachmann and its customers for generations to come.

MORE INFO www.bachmann.info/en/industries/wind-power

MAINTENANCE

Rope Partner gets new investors for turbine service demand

Rope Partner, Inc., an international leader in wind-turbine blade repair, maintenance, and performance-enhancing services, has been acquired by funds advised by Magnesium Capital LLP (Magnesium).

In the last decade, the global wind market has rapidly expanded, with the majority of operating capacity installed since 2009. Providing the required operations and maintenance (O&M) services for these existing turbines as they enter the second half of their design life creates an evolving need for high-quality wind technicians to efficiently and safely service this sector.

With the global wind industry forecast to more than double by 2027 (adding 65 GW annually), the global O&M market is projected to be a \$21 billion market by 2025. The offshore market alone is expected to grow by 17 percent annually, to more than \$12 billion by 2028. This investment will support Rope Partner's continued work to provide the expanding market with the high-quality services critical to supporting and accelerating the transition to a clean energy economy. This includes strategic growth plans in North America and abroad, with Europe and Latin America already identified as key growth markets.

"Since our beginnings in 2001, we have become the leader in the space and have a global reputation, with our services relied on by many of the world's largest wind-energy owners

and manufacturers," said Eric Stanfield, Rope Partner CEO. "This next phase of growth is a very exciting time for us. We see many opportunities in the North American market, both onshore and offshore, and also in Europe and Latin America, where our customers already have wind turbines operating."

Rope Partner, headquartered in Santa Cruz, California, is recognized internationally as the premier at height service provider of repair, maintenance, and performance-enhancing services for wind-turbine blades. With more than 100 highly qualified technicians, the company counts among its clients more than 40 blue chip wind-energy asset owners and OEMs in North America and abroad, and, over two decades, has developed an unparalleled quality and safety record. In the last 18 years, the company's technicians have completed several thousand

projects for every major manufacturer and a majority of the wind-farm owners in North America.

"The industry has evolved significantly over the last several years," Stanfield said. "As the wind farms mature along with the market, customers are placing additional focus on the condition of their blades. As such, it is important for us to keep innovating to safely deliver value to our customers. In Magnesium, we have found a partner with a deep understanding of our core market, an established network in Europe, and the financial backing to respond to our customers' requests. With this infusion of capital, we can develop new services and expand internationally, including through potential acquisitions to consolidate what today remains a fragmented sector."

"Eric and his team have developed a great company over the years with a strong culture of safety, quality, and



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environmental sustainability that is committed to maximizing uptime and ROI for its customers,” said Magnesium’s managing partner Ian Jones, who joins the board of Rope Partner. “The focus on optimizing wind-turbine performance will help accelerate the energy transition by supporting the decarbonization of the electricity system. We look forward to working with Eric and his team through its next

phase of growth.”

“We are delighted to partner with Magnesium and Rope Partner to support the team’s continued growth plans,” said Andrew Carnwath, director of Private Equity at BMO Global Asset Management. “The company has established an unrivaled reputation within the industry, and it is now well placed to benefit from growth in the wind sector and increasing focus on

blade maintenance. We are therefore confident that our investment will provide our investors with a market leading return and have a wider positive impact through growth in sustainable and affordable renewable energy and high skilled job creation.”

MORE INFO www.ropepartner.com

▀ MAINTENANCE

Pure Safety Group introduces stronghold quick-switch system

Pure Safety Group (PSG) recently launched the Stronghold® Quick-Switch® Tool Tether System for the prevention of dropped objects during work at height. The system is based on the proprietary Quick-Switch design, the only technology that allows workers to switch tools from one connection point to another in a single motion to provide a level of dropped objects safety unmatched in the industry.

The Quick-Switch system keeps tools connected at all times, including when they are transferred or handed off. With Quick-Switch, tools can be carried, managed, and used at height while protecting people and property below. The Quick-Switch system gives workers the flexibility to use multiple tools at their work areas and switch tools, all while keeping them connected through a patented combination of keys, links, and anchors. Keys allow the use and manipulation of the tools. Links are the mechanism that allows the switching of locations of tools. Anchors are the points that support the tool in the event of a drop.

The Quick-Switch system components include:

- ▀ Quick-Switch Starter Pack that includes everything needed to get started with the Quick-Switch system: four Quick-Switch Links, one Quick-Switch Bungee Tether, and one Quick-Switch Wrist Cuff.

- ▀ Quick-Switch Link and Dock: Links are paired with tools and are the



Rope Partner is recognized internationally as the premier at height service provider of repair, maintenance, and performance-enhancing services for wind-turbine blades. (Courtesy: Rope Partner)



The Quick-Switch system keeps tools connected at all times, including when they are transferred or handed off. (Courtesy: PSG)

mechanism that makes Quick-Switch the only tethering system in the world that allows movement of tools from one place to another without ever having to be untied. Each link comes with its own dock.

- ✔ Quick-Switch Wrist Cuff.
- ✔ Quick-Switch Bungee Tether, for tethering tools to a belt or fixed structure.
- ✔ Quick-Switch Retracting Tether for retractable applications.
- ✔ Quick-Switch Apron for use over handrails and railings.
- ✔ Quick-Switch Rotating Dock: the anchor point for the Quick-Switch system that can be used on pouches and tool pockets.
- ✔ Quick-Switch Tethered Tool Bucket and Bolt Bag and Tool Holder to contain anchors.

“According to the National Safety Council, every 10 minutes someone is injured because of a dropped tool,” said Matt Moreau, product manager, dropped objects and foreign material exclusion (FME). “Until now, there was no way to transfer tools, hands-free, and maintain 100 percent tie-off.”

Moreau notes that the Quick-Switch products meet the latest OSHA and ANSI standards for drops prevention.

The new Quick-Switch system is the first product launch for PSG’s newly

branded Stronghold family of dropped objects prevention line. Stronghold is the brand that evolved from Ty-Flot, which was the company PSG acquired

in 2018. Stronghold is one of three PSG brands that also includes Guardian® Fall Protection and Checkmate®, both fall protection product brands. Products from all three brands are increasingly available throughout the world, as part of PSG’s recent global expansion.

MORE INFO www.puresafetygroup.com

✔ CONSTRUCTION

Northstar, IntelStor partner to quicken segmented tower tech

Northstar Endeavors LLC of Omaha, Nebraska, recently signed an agreement with IntelStor LLC to provide services related to the commercial adoption of Northstar’s segmented wind-turbine tower technology.

The wind turbine tower market has

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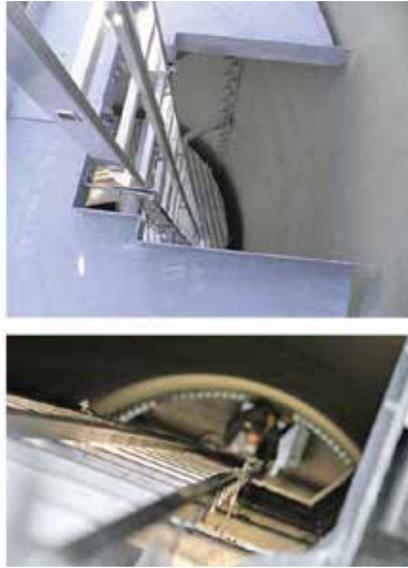
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The Northstar design can be factory pre-assembled in segments and shipped to a project site on standard flatbed trucks instead of extra-long, heavy hauler trucks typically required for a conventional wind turbine tower. (Courtesy: Northstar Endeavors)

long been dominated by conventional conical steel tube towers. As the industry seeks to exploit lower speed wind regimes with an emerging generation of larger wind turbines, new solutions for an economical wind turbine tower that is both tall and transportable will be required.

The benefit of the Northstar design is that it can be factory pre-assembled in segments and shipped to a project site on standard flatbed trucks instead of extra-long, heavy hauler trucks typically required for a conventional wind turbine tower.

This eliminates the need for special permits and eliminates the need for height restrictions for bridges and tunnels during tower transport. That opens up the economic viability of more wind-turbine project sites globally by reducing total installed cost.

Recent independent research indicates that the total transportation and installed cost of a segmented tower can actually be significantly less costly than other commercial solutions due largely to these lower transportation costs.

For truck transport, the logistics cost on a segmented tower can actually be between 50 and 80 percent cheaper than a conical steel tube tower of the same hub height due to the

avoidance of heavy haulers in favor of standard flatbed trucks that require no special permits.

The savings on the transportation costs are further augmented by the reduction in installed costs, which can add up to an additional 14 to 23 percent depending on project site logistics and tower height. In spite of some need for on-site tower assembly, the pre-fabricated tower segments are simple to manipulate and do not require construction personnel to be suspended at height to complete any fittings.

Additionally, due to the segmentation of the tower, the tower base diameter can be allowed to expand between 6 to 8 meters depending on hub height. This wider base allows for better loads distribution and less material usage, which can lead to a cost savings which is upwards of 12 to 18 percent versus a conventional conical steel tube tower of the same height.

This can result in a total cost reduction of between 31 and 48 percent for a reference tower with hub heights of 120 to 160 meters using Northstar technology versus a steel tube tower or concrete / steel tube hybrid tower of the same hub height.

“We’re pleased to be partnered with IntelStor on this project, and this tech-

nology has been developed for more than a decade and proven through the installation of a prototype,” said Jeff Willis, president of Northstar Endeavors. “Our DNV GL certified design for a hub height of 80 meters allows us to serve as a bankable, verifiable option for the next decade of global wind energy growth.”

The Northstar tower technology is scalable for hub heights above 160 meters, which will become more common as project developers seek to repower projects or install new wind turbines that are 5-MW plus.

According to the agreement, IntelStor will be responsible for pursuing a technology license or asset acquisition agreement with a technology commercialization partner. Negotiations are already underway with interested parties, including tower vendors, wind turbine OEMs as well as EPC contractors in multiple countries.

MORE INFO www.intelstor.com/nda

INNOVATION

Aerox to market its leading-edge protection system

The company Aerox has just brought to market its leading-edge protection system for wind turbine blades; 20 months of work have been necessary to scale up the manufacturing and application processes of Aerox AHP LEP



The European Commission selected the project in 2018 to be funded under the SME Instrument scheme of the Horizon 2020 program. (Courtesy: Aerox)

System, the innovative solution of the company for the protection against erosion of the leading edge of wind turbine blades.

Aerox has accomplished the main objectives of the LEP4BLADES project, developing new manufacturing and application processes that have been validated by wind turbine OEMs and service companies.

“This project has been a success for the company, something that could not have been possible without the collaboration of renowned international institutions such as ORE Catapult, University of Limerick, and University CEU Cardenal Herrera of Valencia as well as the support of reference industrial partners in the sector,” said Raúl Cortés, Aerox CEO.

The results of the work carried out in collaboration with the Spanish service company GDES Wind were revealed at the Wind Turbine Blade Manufacture Conference in Dusseldorf last December. The conference, sponsored by Aerox in the 2019 edition, is the most important international industry event on design, materials, production and performance of wind-turbine blades.

MORE INFO www.aerox.es

▀ INNOVATION

Onyx Insight, Castrol partner to deliver oil sensor study

ONYX InSight, a leading provider of predictive maintenance to the wind industry, together with Castrol, one of the leading experts in industrial lubricants, has embarked on a multi-phase study designed to uncover the potential of combining oil and vibration data on the accuracy of wind turbine health monitoring.

With the objective to bring the most innovative and advanced predictive maintenance solution to the wind industry market, ONYX InSight and Castrol have completed laboratory



Combining oil data with vibration data may offer significant diagnostic advantages that improve maintenance planning across a turbine or fleet when deployed together with machine learning and engineering expertise. (Courtesy: ONYX InSight)

testing to measure the effectiveness of sensors to the changing conditions of oil in a simulated wind-turbine environment. The tests were carried out using a range of oil-sensor technologies, with each sensor type tested in multiple oils from three separate vendors to ensure comprehensive results.

The second phase is now in progress and has seen a rigorous program of oil-sensor installations in a commercial wind farm. Data from the field shows excellent correlation between oil sensor and vibration condition monitoring system (CMS) outputs relating to a developing gearbox bearing failure — giving operators even more confidence in the detection algorithm. The trials are helping ONYX InSight and Castrol refine new approaches for an advanced, integrated CMS by combining data from oil condition, vibration sensors and supervisory control and data acquisition (SCADA) systems.

The pioneering study comes in response to the industry’s need to increase efficiencies to help lower levelized cost of energy. The businesses believe that combining oil data with vibration data offers significant diagnostic advantages that improve maintenance planning across a turbine or fleet when deployed together with machine learning and engineering expertise.

“Current predictive maintenance solutions can already offer significant O&M cost-savings,” said Bruce Hall, CEO, ONYX InSight. “By adding an additional data stream through com-

binning oil and vibration data, accuracy increases. This allows our customers to generate even higher cost savings.”

“As wind farms find their profits increasingly squeezed in the post-subsidy market, it is vital to enable O&M teams to drive maximum operational efficiencies using the latest technology,” he said. “To continue to innovate and improve predictive maintenance best practice, we need to understand how oil and vibration data can be combined to provide the most accurate insights to enable us to best support our customers’ O&M teams.”

“As we work toward a more sustainable future, an important part of our strategy is to ensure that renewable energy sources, such as wind power, can achieve maximum efficiency and performance,” said Phil Booker, international application engineer, Castrol. “We have been at the forefront of supplying best-in-class carbon neutral lubricants to extend wind-turbine lifecycles. Now we are working with ONYX InSight to ensure that O&M teams have the knowledge they need to help propel growth in wind energy.”

The study comes as ONYX InSight prepares to launch the first in a series of digitalization reports that incorporates key findings from the combined oil sensor study along with additional research, to help companies rationalize the volume of data in the wind industry to help unlock the benefits of digitalization.

MORE INFO onyxinsight.com

▀ INNOVATION

OFS announces new vibration sensor fiber

OFS, a leading designer, manufacturer, and supplier of innovative fiber-optic products, recently introduced its AcoustiSens Wideband single-mode vibration sensor fiber. The fiber is designed to enhance distributed acoustic sensing (DAS) systems.



AcoustiSens Wideband single-mode vibration sensor fiber is based on the ITU-T G.657.A1 waveguide for enhanced bend insensitivity and includes an expanded operating band to ensure interoperability with all known DAS interrogators. (Courtesy: OFS)

Improving on recent AcoustiSens products, Wideband is based on the ITU-T G.657.A1 waveguide for enhanced bend insensitivity and includes an expanded operating band to ensure interoperability with all known DAS interrogators. AcoustiSens optical fiber, when coupled via sensing cables to commercially available DAS systems, enables significant improvements in acoustic signal-to-noise ratio (ASNR) through dramatic gains in the optical signal-to-noise ratio (OSNR) of the fiber. Splice-compatible with ITU-T G.657 and G.652.D telecom-standard fibers, AcoustiSens Wideband fibers simplify sensor fiber selection while improving system performance.

“Adding to the original AcoustiSens advantages of enhanced Rayleigh backscatter with low loss, we now include improved bend-insensitivity and a much wider operating band,” said Mike Hines, market manager for OFS. “AcoustiSens helps by meeting the challenge of greatly increasing Rayleigh backscatter while maintaining low attenuation, thereby improving OSNR within the fiber. This translates to dramatic improvements in DAS ASNR at the systems level.”

“The OFS specialty team is uniquely positioned to support development of next generation DAS systems with AcoustiSens as an enabling component,” said Adam Hokansson, OFS fiber value stream manager. “By adding im-

proved bend insensitivity, design and manufacturing of DAS sensing cables is simplified. Furthermore, by expanding to an operating band of 1,536-1,556 nm, AcoustiSens Wideband is now compatible with all known DAS interrogators.”

MORE INFO www.ofsoptics.com

INNOVATION

HARTING, Expleo Group cooperate on IoT solutions

The HARTING Technology Group and Expleo concluded a cooperation agreement at the SPS Trade Fair 2019 in Nuremberg. The agreement was signed by Philip Harting, chairman of the Board of the HARTING Technology Group, and Peter Seidenschwang, head of Industry at Expleo Germany GmbH.

It is a reaffirmation of the long-term cooperation by the two parties in the area of data-controlled services and IoT solutions for industrial customers. HARTING is offering the modular edge computing MICA®, which has been designed according to industrial standards for multiple industrial applications, and Expleo is contributing its know-how in connectivity and data-scientific competence.

The joint memorandum of understanding by the management of both



At the HARTING stand at the SPS 2019, Expleo's Industrie 4.0 Showcase demonstrated how production data can be compiled by the edge computing device MICA and evaluated in the SmartANIMO application. (Courtesy: HARTING)

companies is the culmination of many years of successful cooperation in MICA.network, the user organization supporting HARTING's edge computing system MICA®. Expleo has been involved in the network since 2016, working on the development of a solution for the process and operational optimization of machines and production systems. On the basis of compiled data, the SmartANIMO application from Expleo can independently learn the standard behavior of connected production lines and individual machines and use this know-how to identify deviations in the process without manual interventions.

Detecting any upcoming problems at an early stage means that the overall efficiency of the system can be improved with a focus on predictive quality or predictive maintenance. The robustness and flexibility of MICA® also enables Expleo to implement the solution in industrial environments and to retrofit existing production systems non-invasively.

MORE INFO HARTING-usa.com

MANUFACTURING

Vestas secures 155 MW order from Stena Renewables AB

Vestas recently secured a 155 MW order from Stena Renewables AB for the Åby-Alebo wind energy project. Located in Mönsterås Municipality, the project will be the largest wind energy project in the southern part of Sweden.

To maximize the project's power production, Vestas has developed a customized wind energy solution that features 36 V150-4.2 MW turbines in 4.3 MW power optimized mode.

The order underlines the strong relationship between Vestas and Stena Renewables AB as well as Vestas' leading position in the Swedish wind energy market where the company today has installed more than 4.2 GW of wind turbines.

“Stena and Vestas have a strong and long relationship that goes back 15 years,” said Peter Zachrisson, CEO Stena Renewable AB. “Vestas has proven to deliver high availability in our operating assets, which is the result of high-quality products and strong performance in the daily operations. We believe that the optimized V150 is a very good fit for the Åby-Alebo project, and we look forward to develop our strong relationship in this specific project.”

“We are delighted to continue our strong collaboration with our valued business partner Stena Renewables AB,” said Nils de Baar, president of Northern & Central Europe. “This order further strengthens our market-leading position in the Nordics and also emphasizes our ability to deliver energy solutions that offer the lowest cost of energy to the Swedish energy consumers.”

The project will feature a VestasOnline® Business SCADA solution, lowering turbine downtime and thus optimizing the energy output. The contract also includes supply, installation, and commissioning of the wind turbines, as well as a 30-year Active Output Management 5000 (AOM 5000) service agreement.

Turbine deliveries are expected to begin in the second quarter of 2021, while commissioning is planned for the third and fourth quarter of 2021.

MORE INFO www.vestas.com

MANUFACTURING

Luxcara, Vestas agree to close turbine supply for 160 MW in Finland

Luxcara, an independent asset manager in the global renewable energy market, and Vestas have closed turbine supply agreements and long-term service agreements for the three wind projects Vålikangas, Pihtipudas, and Sievi. Vestas has developed a customized wind energy solution that features 38 V150-4.2 MW turbines with

site specific towers, capable of optimizing annual energy production and offering competitive levelized cost of energy.

“We are very much looking forward to working together with Vestas on our Finnish portfolio,” said Dr. Philip Sander, managing partner of Luxcara. “We are convinced that the projects will benefit from Vestas’ expertise in the Nordics and that the selected turbines will ensure the best possible use of the very good wind conditions to produce clean and sustainable energy.”

“I would like to thank our customer, Luxcara, for the confidence they have shown in the capabilities of our 4-MW platform and our services,” said Christer Baden Hansen, vice president, sales North & West, Vestas Northern & Central Europe. “We believe that the three projects will benefit from the V150-4.2 MW turbine’s extremely competitive levelized cost of energy and its perfect fit with the site’s wind conditions. The order affirms the competitiveness of

Vestas’ wind power solutions and that wind power provides an attractive long-term energy investment, capable of delivering beyond its climate and sustainability benefits.”

The wind projects are in the Northern Ostrobothnia region and benefit from favorable wind conditions near the shore.

Together they will provide more than 140,000 households with clean energy. The wind projects have been acquired for a portfolio for institutional investors advised by Luxcara.

The contract includes supply, installation, and commissioning of the wind turbines, as well as a 25-year Active Output Management 5000 (AOM 5000) service agreement. The project will feature a VestasOnline® Business SCADA solution to lower turbine downtime and optimize the energy output. Turbine delivery is scheduled for the second quarter of 2021. ↪

MORE INFO www.vestas.com

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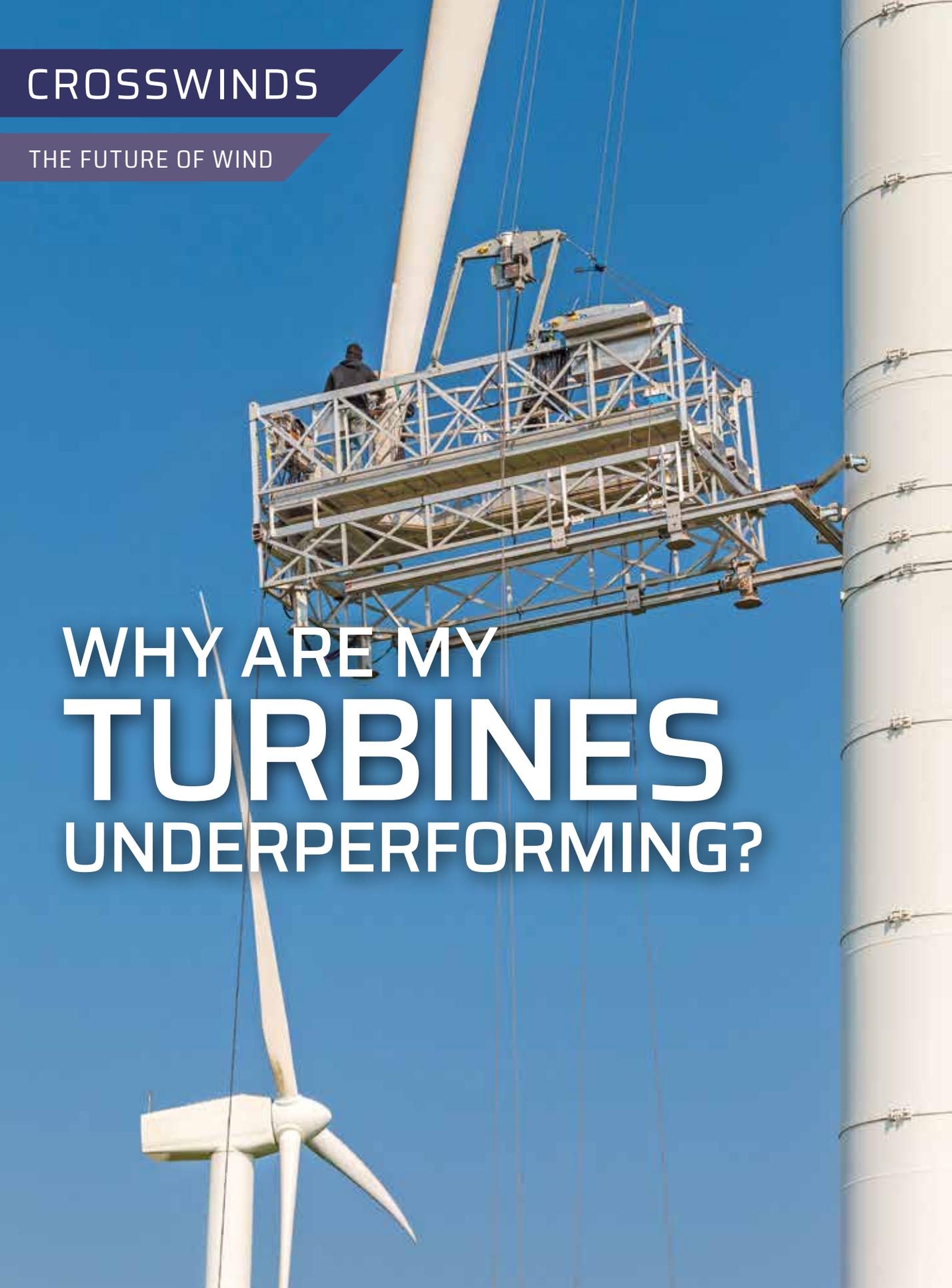
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WHY ARE MY TURBINES UNDERPERFORMING?

By using advanced digital tools to not only identify underperformance, but to understand the reasons behind it, owner-operators can maximize energy production across their assets, regardless of wind resource.

By GARETH BROWN

Wind power has come a long way in the past decade. Thanks to billions of dollars of investment, wind power has grown faster than any other renewable energy source in the U.S. As investors such as BlackRock announce their commitment to divest from fossil fuels, the wind sector is likely to see even more growth.

Investment comes with a clear expectation that wind projects will hit their forecasted power output. However, as we saw in 2019 with Ørsted, even the largest and most established names in the industry can suffer as a result of missed forecasts. To avoid this, owners and operators must ensure that their turbines are operating at peak performance and making the most of the available wind resource.

However, many performance issues are not easily identified through the vast quantity of data — often poorly labeled — that a wind farm feeds back to the owner. For example, a 2-percent dip in turbine performance due to blade pitch misalignment can be difficult to identify from SCADA data alone, especially as a fluctuating wind resource provides an easy scapegoat for an asset achieving a lower output than expected.

In order to understand the true causes of asset under-

performance, digital tools are crucial for rapidly sorting through and comparing data streams. Clir has developed an advanced algorithm, driven by artificial intelligence (AI), which allows the company to identify not only when the turbine is underperforming but indicates what is causing the underperformance. This gives asset owners the information they need to act and ultimately increase their asset's annual energy production (AEP). (See Figure 1)

Through analyzing data from more than 6 GW of assets globally through its platform, Clir has identified a number of common underperformance scenarios that are easily missed through traditional data analysis methods:

THE WAKE EFFECT

Trees, tall buildings, and even other turbines across the wind farm can change the behavior of the wind resource in its wake for hundreds of meters. A more turbulent wind resource leads to a greater fatigue load on the turbine, decreasing its generating potential and increasing wear-and-tear. As such, the impact of tall structures on the ability of downwind turbines to generate energy as forecast can be enormous.

Last year, Ørsted revealed that the blockage effect had caused a 2-percent decrease in AEP for their offshore assets

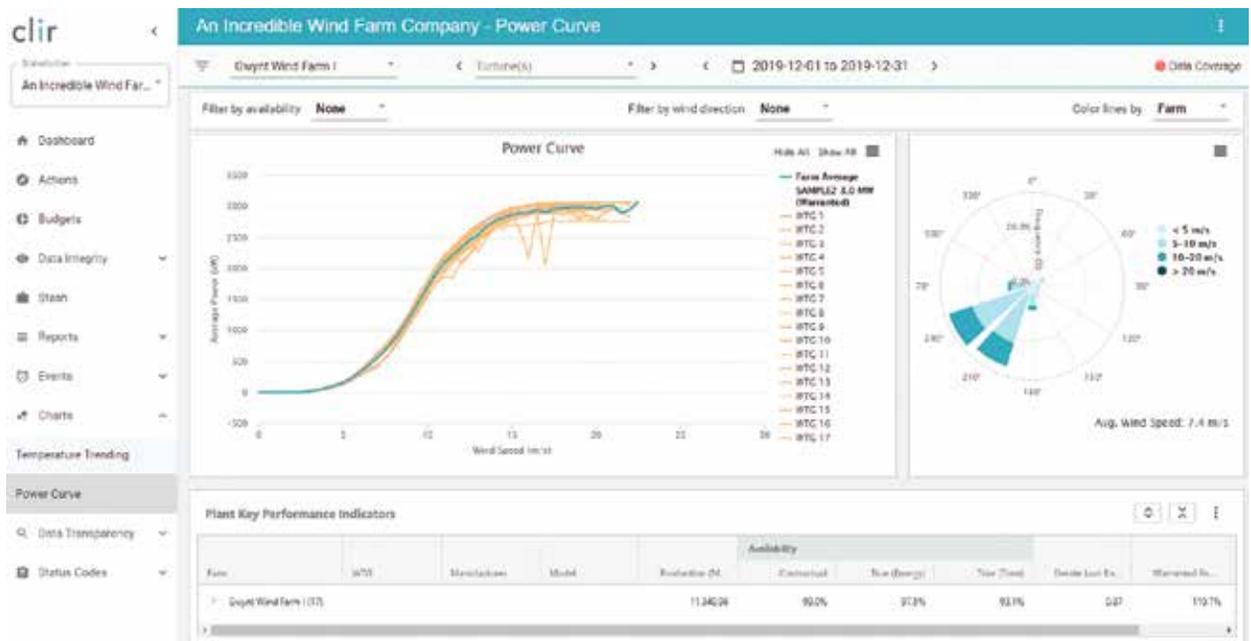


Figure 1: Waterfall chart displaying distribution of energy. (Courtesy: Clir Renewables)



Figure 2: Evidence for a client's turbine having static yaw error. Power production is maximized when the turbine appears to be +8 degrees misaligned with the recorded met mast wind direction, i.e. true wind direction. (Courtesy: Clir Renewables)

compared to the forecasted output. While it's key that the impact of the blockage effect on wind-farm output must be better accounted for in forecasting, there are a number of cases where this effect can actually be reduced.

Analyzing both turbine data and environmental data is crucial for adjusting a wind turbine's surroundings to counteract the wake effect. Clir digitizes not only the turbine but the surrounding environment in order to understand the relationship between the asset and the wind resource that reaches it.

For example, for one project Clir fed wind resource data gathered from a forested area surrounding a wind farm onto Clir's platform and compared it with performance data from each turbine. By doing this, Clir could pinpoint exactly which trees were causing a significant wake effect. This informed a targeted felling strategy that, if implemented, could see the owners of this particular wind farm reduce turbulence and fatigue load on the turbines, increasing AEP by 10 percent.

PITCH AND YAW MISALIGNMENT

In order to make the most of available wind resource, the nacelle and blades must be properly oriented to the wind direction. Sensors on the turbine detect the direction of the wind and angle the turbine toward the resource; however, in the course of installation or maintenance, these sensors can be mis-calibrated. This leads to static mis-

► Thanks to billions of dollars of investment, wind power has grown faster than any other renewable energy source in the U.S. ►

alignment of pitch and yaw, driving the turbine nacelle and blades away from the wind resource and slowing the turbine down. Static yaw misalignment by as little as 4 degrees can result in a 1-percent loss in AEP.

For example, Clir was able to identify a client's wind turbine was producing power at its best when the sensors reported the nacelle was misaligned from the wind direction by 8 degrees. Clir's AI compared this result against met mast data, which confirmed the turbine was, in fact, misaligned from the true wind direction. Following realignment, AEP increased by more than 3 percent. In order to sift through the data and find out whether misalignment is occurring as quickly as possible to prevent lost output, advanced digital tools are necessary. (See Figure 2)

'MINOR' DAMAGES AND DEFECTS

Minor faults and damages to turbines and their components are often missed during normal monitoring of a

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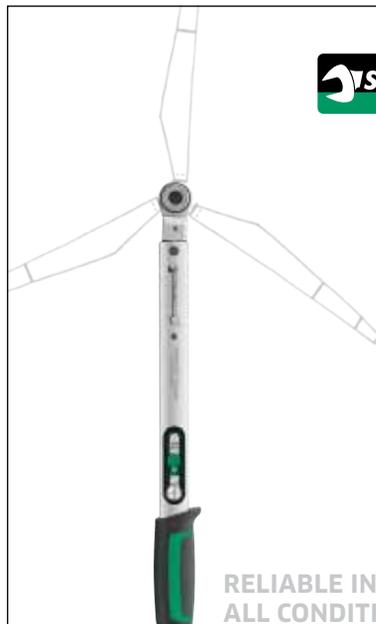
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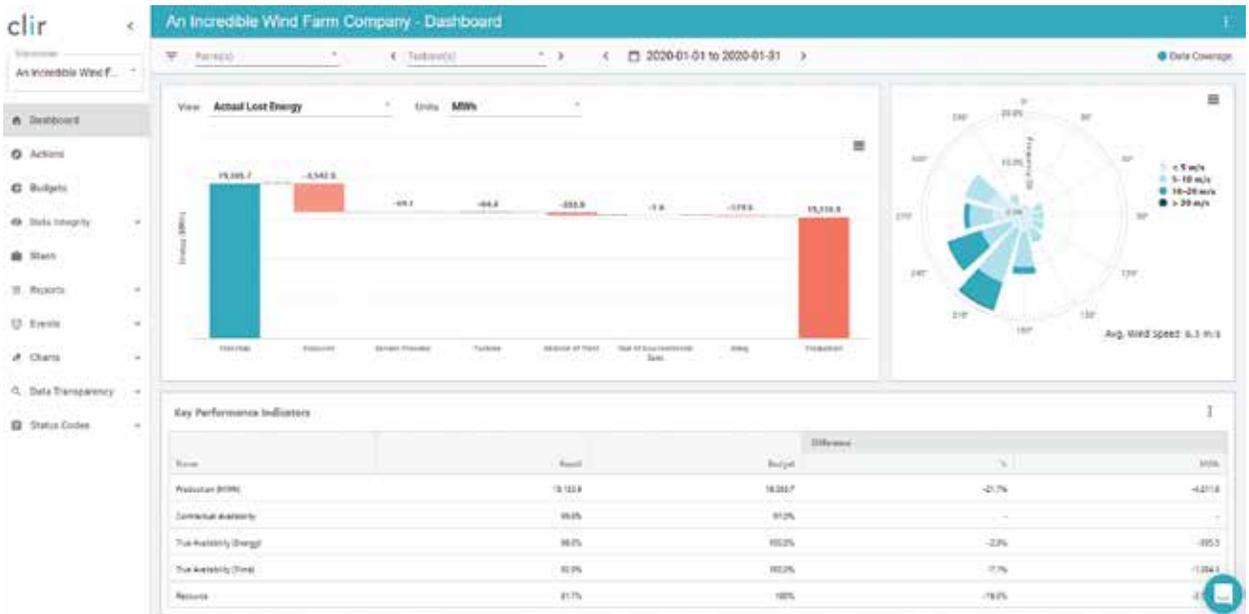


Figure 3: The powercurve for this scenario indicates that while the wind farm's average power production is 3.0 MW, one turbine is being consistently derated to under 2.5 MW. (Courtesy: Clir Renewables)

wind farm. As more owners and operators take a predictive approach to operations and maintenance to reduce the chance of major failure down the line, identifying these faults at the earliest opportunity is more important than ever.

The small damages or faults that preclude a major failure have an effect on turbine performance in and of themselves. For example, a gearbox showing early signs of wear-and-tear will run less efficiently than a fully operational gearbox, and therefore generate less energy. As these “minor” faults build up, there is cumulative loss of AEP.

AI can help identify these low-level faults by rapidly analyzing data and identifying any anomalies. For example, unusual temperature patterns can indicate sensor error or that the turbine is undergoing mechanical stress, indicating damage and potential breakdown. Rather than assuming that underperformance is due to wind resource, AI cross references data across the turbine, environment, and resource, allowing owners to identify, confirm, and fix “minor” issues that would otherwise be missed.

UNNECESSARY DERATING

Derating, or the downregulation of turbine performance, can help limit export to the grid at capacity and prevent wear-and-tear when applied correctly.

Controlled underperformance here is a necessary evil, however, if derating is applied when it doesn't need to be over the course of a year, the wind farm could lose up to 5 percent AEP a year.

Underperformance due to derating tends to be subtle,

with the decrease in turbine performance usually less than 5 percent. It is easy for this level of underperformance to be missed with traditional analysis methods as it can be lost in the noise of influences such as wind resource. In contrast, AI is able to detect derating by identifying regular incidents of underperformance and recognize whether this derating is necessary — informing asset owners and operators of when to rethink their derating strategies. (See Figure 3)

The majority of wind farms across the globe are underperforming without the asset owners' knowledge. Improving turbine performance is crucial not just for increasing energy generation, but for maximizing revenue across the wind farm's operational life.

With more investment channeled towards wind than ever before, owners cannot afford to view underperformance as out of their control. By using advanced digital tools to not only identify underperformance, but to understand the reasons behind it, owners will be able to maximize energy production across their assets, regardless of wind resource. In short, understanding and taking control of turbine performance can be the difference between missing a forecast and exceeding energy production. ✎

ABOUT THE AUTHOR

Gareth Brown is CEO and co-founder of Clir Renewables, a renewable energy AI software company. He is an entrepreneur and a chartered engineer with the IMechE. Brown has more than a decade of experience in the industry that spans the life-cycle of renewable energy projects from identification, development, and construction to financing and operation.

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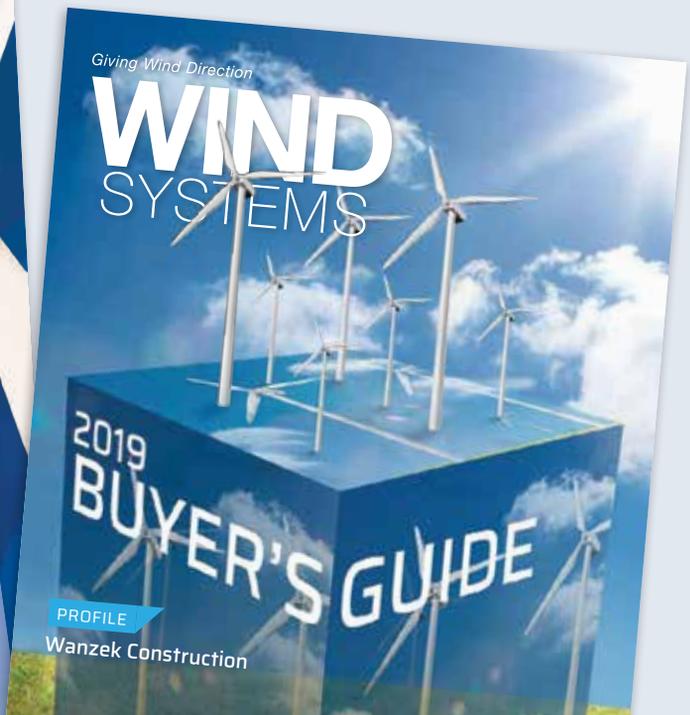
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