Giving Wind Direction

WIND SYSTEMS

inFOCUS: Blades & Gearboxes, Turbine Inspections

» **Profile:** LM Wind Power

OCTOBER 2016

WIND SYSTEMS MAGAZINE
BLADES, GEARBOXES, TURBINE INSPECTIONS
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ALSO IN inFOCUS

SECTIONS

Volume 08 Issue 10

DIRECTION

MAINTENANCE

INNOVATION

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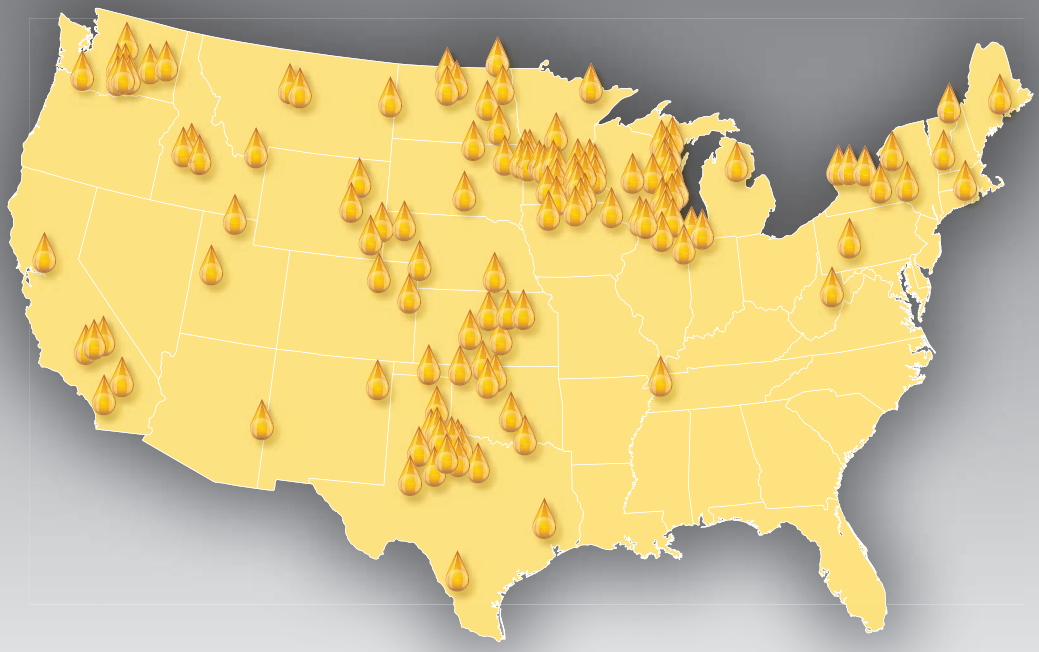

EDITOR'S DESK

OCTOBER 2016

Keep on spinning, spinning, spinning

Kenneth Carter, managing editor
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When conjuring up an image of a wind turbine, what's the first thing that comes to mind?

Is it the tower that juts up hundreds of feet off the ground and into the sky? No. More than likely, the first thought is of those three massive blades, spinning with the wind like some gargantuan piece of modern art.

It can be so mesmerizing, that the realization the rotating blades are actually producing clean, renewable energy might come as an afterthought.

But those blades are critical, whether it's their design and construction or methods to keep them functioning properly throughout their decades-long lifespan.

Blades and the gearboxes from which they sprout are precision components with often delicate dispositions.

That's why companies invest a lot of time and resources making sure the turbines get the utmost care from start to finish.

In the October issue of *Wind Systems*, we focus on blades and gearboxes and the inspection process that keeps turbines in optimum running condition.

We start with our company profile. LM Wind Power, headquartered in Denmark, has been manufacturing turbine blades since 1978. The company is proud of its "big" reputation. How big? It recently created the world's longest turbine blade at more than 88 meters. Want some perspective? If you were standing on the goal line of a football stadium, you'd only be 4 yards short of the *opposite* goal line. Mind blown? Mine was.

But a lot can happen to a blade after it starts its lifetime of spinning. And that's why companies exist to make sure those blades keep on doing what they were designed to do.

Our inFocus for October also features an article explaining new weather technology that aids in assessing lightning damage to wind turbines.

New processes designed to help protect blades from problems such as leading-edge erosion are discussed in an article from 3M Wind Energy.

In the realm of gearboxes, Castrol presents an article that argues transient events, not gearbox oil, is the cause of gearbox failure.

Keeping turbines maintained can often involve a series of complex checks and balances. SKF shares an article about a new monitoring system that would police turbines and flag potential problems before they grow into costly, time-consuming headaches.

That's just a taste of what this month's inFocus section has to offer in addition to our other regular sections highlighting wind power's latest strides and accomplishments.

October's *Wind Systems* is full of interesting wind information. I hope you enjoy reading it as much as I enjoyed presenting it to you.

CONTRIBUTORS

Paul Baker is vice president of sales and engineering for Aerotorque, Inc. Since 2004, he has specialized in wind-turbine drive-train reliability, serves as a presenter at industry events including AWEA, CanWEA, UWIG, NREL, and Sandia, and is a board member of the Northwest Wind Industry Alliance.

Santhosh Chandrabalan leads the 3M Wind Energy business in his capacity as the global business manager. Chandrabalan's background is in composites, and he has spent a significant portion of his career in various leadership capacities in the wind, composites, and solar industries. His past experiences include research in composites, process engineering, engineering management, and global key account management. He holds a BS in Composites Material Engineering from Winona State University and an MS in Engineering Management from Southern Methodist University.

Shylesh Muralidharan is the global product manager at Schneider Electric, focused on building products for real-time weather data analytics integration into energy-industry applications. Muralidharan has more than 14 years of worldwide experience in product management, consulting, and generating thought leadership in the field of new-energy systems and sustainability. A System Design and Management fellow from MIT, Muralidharan has a bachelor's degree in Mechanical Engineering and a MBA from University of Mumbai, India.

Greg Ziegler has more than 30 years experience with machinery protection systems, online condition-monitoring systems, and sensors for industrial applications. For the past eight years, he has served as manager for Business Development at SKF USA Inc. with responsibility for line systems, including the renewable energy business unit for remotely monitoring wind turbines in the U.S. market. He previously managed SKF's condition-monitoring product service business for 12 years.

More Than 120,000 Acres of Offshore North Carolina Up for Lease

As part of President Barack Obama's Climate Action Plan to create American jobs, develop domestic clean energy sources, and cut carbon pollution, U.S. Secretary of the Interior Sally Jewell and Bureau of Ocean Energy Management (BOEM) Director Abigail Ross Hopper recently announced a proposed lease sale for 122,405 acres offshore North Carolina for commercial wind-energy leasing.

The proposed lease is for the Kitty Hawk Wind Energy Area, which BOEM identified in consultation with members of its North Carolina Intergovernmental Renewable Energy Task Force. The task force includes membership from federal, state, tribal, and local government partners. In addition, BOEM considered information gathered through outreach with stakeholders.

"This is an important and exciting milestone in our ongoing efforts to tap the vast wind-energy resources along the Atlantic Coast," Jewell said. "The proposed lease sale is the result of thoughtful collaboration at all levels to identify areas offshore North Carolina with great wind-energy potential, while minimizing conflicts with other important uses. We will continue to work with the North Carolina Renewable Energy Task Force, local communities, and key stakeholders as we move forward with harnessing clean-energy resources, generating jobs, and stimulating local economies."

The area proposed for leasing is the same as the Kitty Hawk Wind Energy Area (WEA) that BOEM announced on August 11, 2014. This WEA begins about 24 nautical miles from shore and extends about 25.7 nautical miles in a general southeast direction. Its seaward extent ranges from 13.5 nautical miles in the north to 0.6 of a nautical mile in the south. It contains 21.5 outer continental shelf blocks. BOEM also announced the Wilmington East and Wilmington West WEAs, which, due to their proximity and shared attributes, have been coupled with the planning and leasing process for the South Carolina Call Areas.

A "Proposed Sale Notice (PSN) and Request for Interest (RFI) for Commercial Leasing for Wind Power on the Outer Continental Shelf Offshore North Carolina" was published in the Federal Register August 16, and includes a 60-day public comment period ending October 17.

This document provides detailed information concerning the area available for leasing, the proposed lease provisions and conditions, auction details (e.g., criteria for evaluating competing bids and award procedures), and lease execution. It includes an RFI to assess whether there has been a change in competitive interest in the area since the publication of the North Carolina Call for Information and Nominations ("Call") in 2012.

"This is a great day for North Carolina and our country as we continue to make progress on diversifying our nation's energy portfolio," Hopper said. "With the completion of a successful lease sale, North Carolina will move closer to obtaining substantial contributions to the region's energy supply from offshore wind. Additionally, such supply will assist local governments in achieving their renewable energy goals."

In order to participate in the lease sale, potential bidders whom BOEM has determined are qualified to hold an OCS lease for commercial wind offshore North Carolina must submit a response to this notice by the end of the 60-day comment period, affirming their continued interest in the area being offered for leasing.

Companies interested in participating in the lease sale that have not been qualified by BOEM must submit the required qualification materials by the end of the 60-day comment period for this notice. Companies planning to submit a qualification package are encouraged to submit as early as possible during the comment period to ensure adequate time for processing. The PSN provides additional information about qualification requirements.

To be eligible to participate in the lease sale, each company must have been notified by BOEM that it is legally, technically, and financially qualified by the time the final sale notice is published.

If BOEM determines that competitive interest in the proposed lease area still exists, BOEM will proceed with the competitive process. If BOEM determines competitive interest in the proposed lease area no longer exists because only one potential lessee is interested in the area, BOEM may proceed with the non-competitive process and negotiate the terms of the lease directly with the interested company.

Comments received electronically or postmarked by October 17 will be available to the public and considered before the publication of the final sale notice, which will announce the time and date of the lease sale.

The announcement builds on BOEM's work to foster offshore renewable energy development through a collaborative state-federal process to identify WEAs and hold competitive lease sales. BOEM has awarded 11 commercial offshore wind leases, including nine through the competitive lease sale process (two offshore New Jersey, two in an area offshore Rhode Island-Massachusetts, another two offshore Massachusetts, two offshore Maryland and one offshore Virginia). These lease sales have generated about $16 million in winning bids for more than a million acres in federal waters.

Source: U.S. Department of the Interior

For more information, go to www.doi.gov

NREL Study Provides Clean-Energy Insights in the Eastern Power Grid

A new study from the United States Department of Energy's (DOE) National Renewable Energy Laboratory (NREL) used high-performance computing capabilities and innovative visualization tools to model, in unprecedented detail, how the power grid of the eastern United States could operationally accommodate higher levels of wind and solar photovoltaic generation. The analysis considered scenarios of up to 30 percent annual penetration of wind and solar.

Whereas previous studies have investigated operations in one-hour intervals, NREL's Eastern Renewable Generation Integration Study (ERGIS) analyzed a year of operations at five-minute intervals, the same real-time interval used by grid operators for scheduling resources.

"By modeling the power system in depth and detail, NREL has helped reset the conversation about how far we can go operationally with wind and solar in one of the largest power systems in the world," said the Energy Department's Charlton Clark, a DOE program manager for the study. "Releasing the production cost model, underlying data, and visualization tools alongside the final report reflects our commitment to giving power system planners, operators, regulators, and others the tools to anticipate and plan for operational and other important changes that may be needed in some cleaner energy futures."

HIGH-RESOLUTION MODEL

For the study, NREL produced a high-resolution model of the entire Eastern Interconnection, including Canada, an important power-trading partner with the United States. NREL modeled more than 5,600 electricity generators and more than 60,000 transmission lines in a power system that spans from Florida to Maine and portions of Canada and as far west as New Mexico.

ERGIS considered four hypothetical scenarios to analyze how the Eastern Interconnection might function in 2026, when the power system could have significantly less power generation from fossil fuels. The scenarios vary according to how wind, solar, and natural gas are used to replace the fossil-fuel generators. The scenarios also differ according to the amount of new transmission lines that are assumed. Simulations occur in a modeling framework that mirrors the security constrained unit commitment (SCUC) and economic dispatch (SCED) process used by system operators. The SCUC and SCED determine the operation of the power system according to a variety of constraints, including marginal costs and defined operating reserve requirements. The capital costs, land use and siting, market design, gas pipeline, and other factors that would need to be addressed under the scenarios were not considered. This study also did not look at all aspects of reliability considered by system planners and operators, including system dynamics and AC power flow.

"Our work provides power-system operators and regulators insights into how the Eastern Interconnection might operate in future scenarios with

more wind and solar energy," said Aaron Bloom, NREL project leader for the ERGIS study. "More importantly, we are sharing our data and tools so that others can conduct their own analysis."

Among other findings, ERGIS shows that as wind and solar power generation increase:

The operation of traditional power sources (such as coal, natural gas, and hydropower) changes — Turning up or down more quickly to accommodate seasonal and daily variations of wind and solar in order to maintain the balance between demand and supply. In addition, traditional generators would likely operate for shorter periods of time as wind and solar resources meet more of the demand for electricity.

Flows of power across the Eastern Interconnection change more rapidly and more frequently. During periods of high wind and solar generation (for example, 40 percent or more of daily load), model regions trade frequently and in large volumes according to new net load patterns.

Regulatory changes, market-design innovation, and flexible operating procedures are important to achieving higher levels of wind and solar. Looking at a year of operations at a five-minute level, ERGIS shows that the power system can meet loads with variable resources — like wind and solar — in a variety of extreme conditions. However, technical feasibility depends on other transmission and generation operators providing the necessary ramping, energy, and capacity services; wholesale market design changes; and various capital expenditures, all of which will have financial and other implications that may need to be addressed and were outside of this study.

ANALYSIS FAST FACTS

- The maximum penetration of wind and solar was 60 percent over a fi e-minute interval.
- The maximum annual curtailment of wind and solar was 6.2 percent.
- Wind and solar generation result in a 30-percent reduction in generation and commitment from coal and natural gas plants in the high wind and solar scenarios.
- Over the baseline scenario, CO2 emissions were reduced by up to 33 percent annually in the high wind and solar scenarios.

PEREGRINE SUPERCOMPUTER

NREL developed new modeling and analytical approaches that were executed using Peregrine, the lab's ultra-efficient supercomputer. Peregrine has a peak performance of 2.25 petaflops (2.25 million billion calculations per second). That combination of computing power and innovative modeling techniques enabled NREL to remove simplifying assumptions included in other power-systems models, increase fidelity of the modeled results, and reduce the processing time for ERGIS calculations from 19 months on a desktop computer to 19 days. The ERGIS team also took advantage of additional resources in NREL's Energy Systems Integration Facility.

"We developed visualization tools that allow us to see how energy moves through the grid in space and time, and through those tools we could see patterns and events that weren't visible in the static data points and plots," Bloom said.

This study was funded by the Energy Department's Office of Energy Efficiency and Renewable (EERE) and the Office of Electricity Delivery and Reliability (OE).

Source: NREL

For more information, go to www.nrel.gov

Business Network for Offshore Wind Opens Office in New Jersey

On the sixth anniversary of Gov. Chris Christie's signing the Offshore Wind Economic Development Act, the Business Network for Offshore Wind, a leader in building the U.S. offshore-wind supply chain, announced the opening of its Woodbridge, New Jersey, office.

"By expanding to New Jersey, which has the potential to provide more than 4 GW of offshore wind power, the Network can continue building a U.S. offshore wind-supply chain, generate additional job opportunities for members and strengthen the emerging U.S. offshore wind industry," said Executive Director Liz Burdock.

"New Jersey has a world-class wind resource far off the shore that can deliver clean, reliable power right where we need it, and the most potential for Atlantic states with current BOEM offshore wind leases," said Doug O'Malley with Environment New Jersey.

Four months after the Bureau of Ocean Energy Management announced New Jersey's 344,000 acres of two wind-energy areas, RES Americas, Inc. and U.S. Wind Inc. bid nearly $2 million in November for the offshore leases. Now, after a transfer of the lease this spring, Dong Energy, the world's largest owner of offshore wind, announced plans to construct Ocean Wind, a 1,000-MW wind farm 10 miles off Atlantic City. Additionally, Fishermen's Energy again won a competitive Department of Energy grant as it moves closer to construction of six turbines off Atlantic City as a ready-made demonstration project.

"Ecology & Environment is a strong supporter of offshore wind development in the United States and is excited that the Business Network is expanding its capable reach into New

Jersey," said Kris Ohleth with Ecology & Environment. "We have seen the positive influence the Network has had in Maryland and look forward to their support in New Jersey. We look forward to working with them to cultivate our state's supply chain and offshore wind development."

Matthew Greller, who was involved in passing the New Jersey Offshore Wind Economic Development Act in 2010, will be the New Jersey director of the Business Network for Offshore Wind. Greller also serves as Of Counsel with Cleantech Law Partners, a boutique law firm specializing in the renewable energy field. Ross Tyler, formally director of Clean Energy for the Maryland Energy Administration, will continue to lead the Maryland Network Office.

The Business Network for Offshore Wind is a 501(c)(3) organization dedicated to creating jobs, strengthening the economy, and improving quality of life through offshore wind. The Network is focused on delivering education, creating partnerships, and advancing the industry. All proceeds are used to support the industry by helping the Network continue education, develop tools, and networks necessary to create a U.S. offshore-wind supply chain.

Source: Business Network for Offshore Wind

For more information, go to www.bizmdosw.org

Thai Wind Investments Come to Fruition

Modern Energy Management (MEM) worked with Gunkul Engineering, a leading Thai renewable electricity producer, to bring three wind projects to financial close. The three wind farms would contribute 170 MW to the grid — nearly doubling Thailand's total wind-energy capacity.

MEM, a specialist in delivering project lifecycle certainty to renewable energy developers, financiers, and investors, served as the owner's representative on the 60-MW Wayu, 60-MW Greenovation, and 50-MW Korat Wind projects. The firm is now acting as owner's engineer for construction on the Wayu project and will fill the same role on the Korat Wind project.

Over the next two decades, Thailand's energy consumption will increase by 75 percent. At the same time, however, much of its current energy infrastructure is to be decommissioned, while its natural gas reserves are expected to run out by 2021.

Faced with these energy supply-and-demand challenges, Thailand is aiming to secure 25 percent of its energy from renewable sources by 2036. As part of these efforts, the country has dramatically increased its wind-power capacity over the past five years — from 5.6 MW in 2010 to 234.5 MW in 2015.

However, in order to realize its goals, Thailand must make the most of its available wind resources and take advantage of the latest technology.

Since all three projects are in medium- to low-wind-speed areas, the wind farms use innovative new IEC Wind Class 3 turbines, which are specially designed to maximize efficiency and output in limited wind regimes. By combining a larger rotor with the ability to select from a range of taller tower heights, these low wind turbines boost performance and will ensure that each project is optimized to maximize generation.

MEM's work on each of these projects demonstrates the advantages of enlisting an independent partner with experience and expertise in new and emerging markets to deliver investment-grade projects, instill investor confidence, and bring projects to financial close.

As part of its work on the three projects, MEM offered contract advisory services, served on project tenders, and provided project management services related to the financial close process. The Wayu project is expected to be complete by the end of 2016, while the Greenovation and Korat Wind projects are set to be commissioned by the end of 2017 and 2018, respectively.

"These projects illustrate how cutting-edge technology continues to be embraced in Thailand and the wider Asian market," said James Munro, project manager at Modern Energy Management. "Incorporating the latest low wind turbines ensures that these wind farms will be able to maximize energy generation even in low wind conditions. In turn, they will deliver long-term, steady returns to project investors."

"Our success in completing the financing of these flagship projects shows that Thai wind is truly an investment-grade prospect," said Janpon Ngamaroonchote, vice president of Strategic Planning and Investment at Gunkul Engineering. "Modern Energy Management's understanding of the market in Thailand, along with its international experience helping to secure financing for early utility-scale developments has been a significant asset — and we look forward to continuing our work with the team throughout construction."

Since 2013, MEM's team has delivered specialist work in more than 20 countries and has been involved in Thai wind since the development of the first utility-scale wind projects. The firm helps to unlock significant financial and operational performance in emerging markets, and has a growing presence across Asia and Africa.

Source: Modern Energy Management

For more information, go to modernenergy.co.th

inFOCUS

Don't Blame the Oil

Transient events — not gearbox oil — are the leading cause of wind-turbine gearbox failure.

By Paul Baker

In the wind industry, complex organo-metallic gear-oil chemistry and its resulting higher water content have sometimes been blamed for gearbox damage or failure. But water in oil is not the cause of gearbox failure. Rather, the characteristics of wind-turbine operations and the resulting transient loads are the root cause of nearly all failures.

Transient loads are the underlying cause of gearbox failure. Common characteristics of organo-metallic oil formulation — those typically using molybdenum-based EP additives — have met with some criticism, but it does not lead to these costly failures. Despite some currently held industry theory, it is inaccurate to attribute gearbox failure to organo-metallic gearbox oil that is able to hold a higher amount of water.

ENVIRONMENTAL TURBINE CHALLENGES

- Lubrication points are subject to dirt, dust, water, high turbulence, and extreme temperatures and can be hundreds of feet in the air.
- Access to offshore installations can be hindered by logistical factors including high seas.

OPERATIONAL AND COMMERCIAL TURBINE CHALLENGES

- Turbines need to run intermittently and at varying speeds, and are subject to a wide range of temperatures from minus-40 degrees C to greater than 50 degrees C.
- High levels of vibration put pressure on moving parts.
- Greater output demand increases the loading on bearings, drives, and gearboxes.

Source: Castrol Wind Turbine Brochure

Castrol

THE CHALLENGES OF WIND EQUIPMENT

Wind-equipment conditions are different than those in any other industrial gearing application.

A wind turbine's substantial load of overhanging weight — combined with varied climate and geographical conditions and consistently unpredictable weather extremes — presents a series of challenges seen only in the wind industry.

In fact, sheer weight has an exponential impact on equipment. For example: A turbine's blades and hub weigh 30 tons — which is supported by one bearing and gearbox with a three-foot generator on the other end — and it's all held 300 feet in the air by a solid-steel shaft two feet in diameter.

The resulting effects of unpredictable conditions can be extraordinary.

TRANSIENT EVENTS

When a wind turbine experiences a transient event — a short-lived burst of energy caused by a sudden change of state — it can be a violent occurrence.

Gears and bearings are designed around specifications for normal operating conditions.

In other industries, normal operating conditions are easy to predict. But with a wind turbine, it is impossible to measure transient loads.

A wind turbine is not, by nature, designed to handle these events.

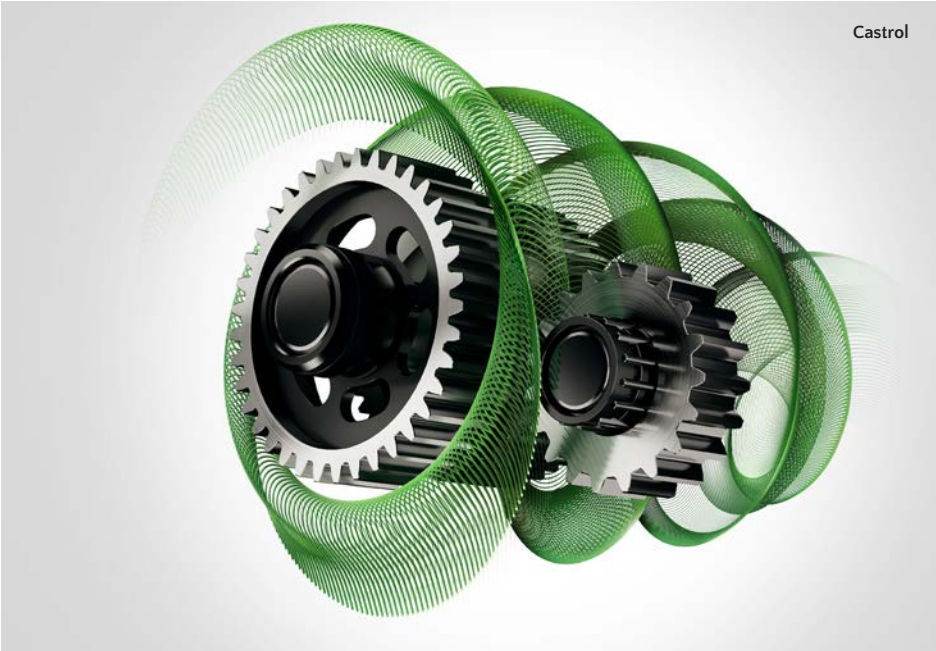
Precision gearing uses clean, high-performance gear lubricant.

What's more, many of these transient events happen hundreds of times a day — for example, with a gust of wind or change of wind direction. As a result, while wind turbines are designed for normal operating conditions, there is no way to anticipate what transient loads might be seen.

I employ the American Gear Manufacturers Association's safety factor to determine normal operating conditions. But while this evaluation applies to typical industrial gearing, this is not the case in wind. The standard safety factor for wind turbines is 30 percent (which falls in between AGMA light and medium duty). Anyone in the industry will say a wind turbine is a heavy-duty application.

Building equipment based on normal operating conditions will

ALSO IN THIS SECTION


Castrol

An X-ray diagram of a wind turbine shows the key mechanical components of a wind turbine and the lubricant necessary.

satisfy 95 percent of concerns. But the remaining 5 percent is what separates the art from the science.

There are ways to monitor the progression of failure in a live machine in order to prevent that failure. Examples of "condition monitoring" tactics include measuring temperature, cleanliness of oil, vibrations the bearings and gear meshes create as they rotate, power output, and power consumption.

But in my experience in monitoring gearbox failure in general and wind-turbine gearbox failure in particular, all of these variable factors should be considered "symptoms." In fact, transient loads are the cause of the actual failure.

STOPPING PROTOCOLS

In my current role, I measure the effects of stopping protocols, and I have found stopping protocols result in more than triple a wind turbine's normal torque, but in the opposite direction. And in some turbines, stopping protocols (which include emergency stops/E-stops) can happen 200 to 300 times a year.

POWER GRID FAILURE

When grid failure occurs, resistance is gone almost instantly. The system can now unwind in the opposite direction of what it is used to, causing torque reversals and "wreaking havoc."

You can have the best gears, bearings, and oil on the planet. You can have diligent ongoing live equipment monitoring. You can work on either side of the design equation, experimenting with handling more load or less load. You can try building with different steel and alter other fabrication elements. But at the end of the day, none of these variables has anywhere near the impact on gearbox failure than the loads themselves.

DOES GEAR OIL CAUSE GEARBOX FAILURE?

As anyone in the wind industry knows, when a gearbox fails, it can be a costly occurrence. It also can lead to the inevitable desire to get to the root of the problem and look to assign blame.

Most turbines that fail are still using their original gear oil fill — so it's not uncommon for managers to group the original oil in with the original equipment when discussing gearbox failure.

But in the wind industry, there are few, if any, lube-related failures.

These OEM first-fill gear oils fall victim to this incorrect theory primarily because of their association with the original equipment. There are certain gear-oil formulations that, even though they offer long-lasting protection for costly machinery, have certain attributes or results that have been called into question on occasion.

But these qualities or visual characteristics do not affect gearbox failure.

WATER IN OIL

A common discussion in the wind industry relates to high-water content in gearbox oil. Overall, the impact of water content in synthetic gearbox oil is dependent upon whether the water content is near the saturation limit and if the water is fully dissolved in the oil.

Certain organo-metallic oil chemistry results in an affinity to water that enables the oil to handle up to five times as much water as some ashless and sulfur/phosphorous-based gear oils. If the oil is formulated to hold a high level of water, then water in that oil is simply not an issue.

Most oils (e.g., ashless) can't capture more than 300 parts per million (PPM) with-

out failing. So, if that oil tests at 150 PPM, it could be a cause for concern, as that water can escape solution, interfere with gears and bearings, and cause corrosion.

WATER AND THE ADDITIVE PACKAGE

Organo-metallic gear oils are engineered to protect and maximize the performance of wind-turbine gwearboxes. Some characteristics of organo-metallic oil with the ability to hold higher levels of water display visible signs. But these conditions do not affect gearbox failure.

Some of these signs include:

Sludge: Due to the complex additive package in these oils, water can react with some of the additives and "fall out of solution." The resulting out-of-solution additives are referred to as sludge. Sludge can collect in the low-flow area of a gearbox and cause staining. But while this may make looking at gearbox damage more difficult, the sludge itself does not cause damage or failure.

Foaming and Micro-pitting: The other condition that can arise from gear oil with a high water content is foaming, caused as the oil churns up and captures air. Foam can sometimes cause a small amount of near-surface micro-pitting — but we are not seeing that it causes any failures, unless foam has replaced oil. In wind equipment, the micro-pitting is more likely attributed to transient loads.

INVESTIGATING TRANSIENT EVENTS

Over the past 12 years, I have inspected a lot of turbines. Nearly all failures are caused by transient loads (which are also peak loads, versus loads under normal operating conditions) — and they happen much more frequently than people suspect.

Specific failures include those attributed to gears and bearings.

Gear Failure: The two leading causes of gear failure are soft metal inclusions and grind temper damage in gear teeth. Interestingly, both of these phenomena exist in 95 percent of the world's gears, but the equipment in other industries typically continues to run no signs of these conditions, and they don't cause damage or failures. But in the wind industry, one peak load can expose these defects.

Bearing Failure: The two most common causes of bearing failures are axial cracks (also called white-etch cracks, so called when the bearing surface and sub-surface fatigue failures are characterized by white edges along the cracks) in roller bearings and spalling in tapered roller bearings. Both of these failure modes are caused by "hard spots" in the steel structure of the bearing. But they manifest differently.

These hard spots deep within the steel structure are known as adiabatic shear bands. In the case of wind-equipment roller bearings, the origins of shear bands can be attributed to peak transient loads. And they are the root cause of the axial cracks and spalling that are, in essence, crack-initiation points.

Hydrogen Embrittlement: Hydrogen embrittlement occurs when metals such as steel become brittle and fracture due to the introduction and subsequent diffusion of hydrogen into the metal. When white-etch cracking was first discovered in wind-turbine bearings, the bearing manufacturer attributed the problem to hydrogen embrittlement and blamed the gear oil. The theory was that if too much water was entrained in gear oil, the steel attracted hydrogen out of the water when heat and pressure were introduced, resulting in hydrogen embrittlement.

I dispute this theory. White-etch cracking/hydrogen embrittlement can't happen unless there is already a crack or inclusion brought on by transient loads. In fact, I hypothesize hydrogen embrittlement may not even factor into the problem at all if adiabatic shear bands already exist.

Given the factors that are unique to the relatively young wind industry and my extensive examinations of wind turbines and their gearboxes

TRANSIENT EVENTS THAT CAN 'WREAK HAVOC'

Transient events, which are also peak loads, have everything to do with wind-turbine failure. Even if they happen often, they are not considered normal operating conditions.

Examples of transient events include:

- Wind shear, when wind comes at a blade at an odd or obtuse angle
- Wind gusts
- Changes in wind direction
- Startups, shutdowns, and emergency stops
- Failure of power grid

EXTREME CONDITIONS: HOW A TURBINE OPERATES

- Three massive blades capture enxergy from wind. The power it captures and the thrust of it is tremendous. The bladesr 300-foot diameter equals high inertia created at the end of the blade.
- Wind thrust is converted into rotational energy (high torque/low speed). Turning this main rotor shaft at 15 RPM on average.
- Rotational energy is transferred into the gearbox at 15 RPM, which changes high torque/low speed energy into high speed/low torque energy for the generator. Gear ratio is typically 100:1.
- The gear ratio increases the rotational speed from 15 RPM to 1,500 RPM to drive the generator and make electric power.

> It's the transient events that have everything to do with wind-turbine failure.

for more than a decade, I concluded that, despite some industry theories, the presence of water in gear oil that is formulated to hold a high level of water is not an issue. In fact, water in these oils cannot be linked to gearbox failure.

Unless the oil being used is not correct for the application — for example, mineral oil being used in an extremely cold climate — the best solution is to stay with a wind turbine's original oil fill product to avoid potential problems.

IN SUMMARY

Through my lengthy tenure and hands-on experience in the wind industry, I confirm water content in gear oil is not the cause of gearbox failure.

Rather, gear-and-bearing failure can be attributed to the transient events that occur hundreds of times per year — the effects of which can never be predicted in equipment that has been designed for normal operating conditions.

You can have the best gears, bearings, and oil on the planet. You can have diligent ongoing live equipment monitoring. But it's the transient events that have everything to do with wind-turbine failure.

FOR MORE INFORMATION

Castrol has more than 30 years of experience supporting the wind-energy industry, supplying lubricants to thousands of wind turbines and providing global product support services. In addition, BP, Castrol's parent company, is one of the largest wind-park owners in the United States, with a gross generating capacity of approximately 2,600 MW, which equates to electricity to power more than 775,000 average American homes.

Castrol's global reach provides access to a worldwide network of sales, engineering, research, and manufacturing capabilities to support wind-farm operations and maintenance needs. A network of specialist service companies also supports oil-change procedures in line with the requirements of wind-turbine OEMs. For more information, go to www.castrol.com/windenergy.

Adwen and Winergy Develop the World's Biggest Gearbox

Adwen/Winergy

The AD 8-180 at the assembly plant.

Adwen and Winergy have developed the biggest gearbox in the world for Adwen's AD 8-180 offshore wind turbine. With an input torque of close to 10,000 kilonewton-meters (kNm) and a weight of 86 metric tons, it is the largest wind turbine gearbox ever built.

Winergy's gearbox was designed exclusively for the AD 8-180 wind turbine. It is part of a medium-speed drive-train concept that will considerably help reduce the levelized cost of energy (LCoE) on Adwen's new offshore giant. At 180 meters, the AD 8-180 boasts the world's largest-diameter rotor. In combination with a nominal electrical power of 8 MW, the gearbox attains an input torque of close to 10,000 kNm — a value never before equaled.

This 70-percent increase in torque capacity was achieved with only a 20-percent weight increase compared to other gearboxes used in offshore wind turbines larger than 6 MW. The two-stage-planetary gearbox is directly connected to a medium-speed generator via a flange connection. Thanks to the choice of a medium-speed gearbox concept and leveraging on proven technologies well-known by both companies, Adwen and Winergy can successfully maximize the efficiency of the drive train, while cutting the cost of the components. In tests, the gearbox attains an efficiency of well over 98 percent. Further, by reducing the built-in components, its reliability increases.

Winergy has manufactured four gearboxes for Adwen with the goal of having them fully validated in three phases. The first one will be at Winergy on a modified test bench being used for the back-to-back testing of two identical gearboxes with up to

125 percent over loading. Adwen's validation process, the most stringent ever taken on a gearbox and drivetrain this size, requires these tests to guarantee maximum reliability of this critical component.

The second phase will be at Fraunhofer IWES Test Center's Dynamic Nacelle Testing Laboratory where the gearbox will undergo exhaustive tests in combination of full drivetrain and nacelle. The final phase is field tests with the installation of the AD 8-180 prototype in Bremerhaven, Germany.

"We continue pushing the limits of the industry with our AD 8-180, this time with the largest gearbox ever built," said Adwen CEO Luis Alvarez. "This key component has performed extremely well during the exhaustive validation process which makes us confident the first prototype of the turbine will meet and even exceed our expectations in terms of performance and reliability when it is installed. In addition, as the rest of the main components, it has been designed with scalability in mind enabling the future evolution of the platform."

"Particularly in the offshore sector, reliability is the essential thing," said Winergy CEO Aarnout Kant. "With this medium-speed gearbox concept, we are demonstrating our technological expertise and innovative strength.

The AD 8-180 is the world's largest gearbox.

The integrated drive system is not only very compact and efficient, it is also extremely reliable. It makes us proud to be Adwen's partner on this showcase project."

The dimensions of the gearbox designed for the AD 8-180 wind turbine were showcased at WindEnergy in Hamburg, Germany, in September.

Source: Adwen

For more information,
go to www.adwenoffshore.com

A Bolt of Knowledge

Weather-forecasting advances shed new light on lightning damage to wind turbines.

By Shylesh Muralidharan

A carbon-fiber blade from a wind turbine is transformed into shards of debris as it is struck by 30,000-degree lightning.

This disastrous — and costly — scenario is not an uncommon sight for wind-farm operators. But not all lightning damage is so obvious.

After a storm, those tasked with managing and maintaining wind turbines have a challenge: Does each turbine necessitate manual, costly, and time-consuming inspection for lightning damage? Or do wind-farm operators take the risk of operating a damaged turbine, potentially leading to greater issues?

Lightning, the leading cause of turbine-blade damage and unplanned turbine outages, is the greatest operational hazard affecting the fastest-growing source of energy in the world. And, these damages are not easily repaired. Energy companies spend millions in short- and long-term repair, replacement, and upgrades.

Wind farms, though an effective and clean source of energy, possess properties that make them vulnerable to lightning. Beyond the fact they are giant spires often in the middle of a flat field, turbines are constructed from insulating materials.

This predicament poses a particular challenge for wind-farm operators. A turbine struck by lightning can sustain critical damage, but the damage may be imperceptible to the naked eye. Even the use of strike-tracking technology to observe a lightning-producing storm is minimally helpful to those developing the following day's maintenance plan.

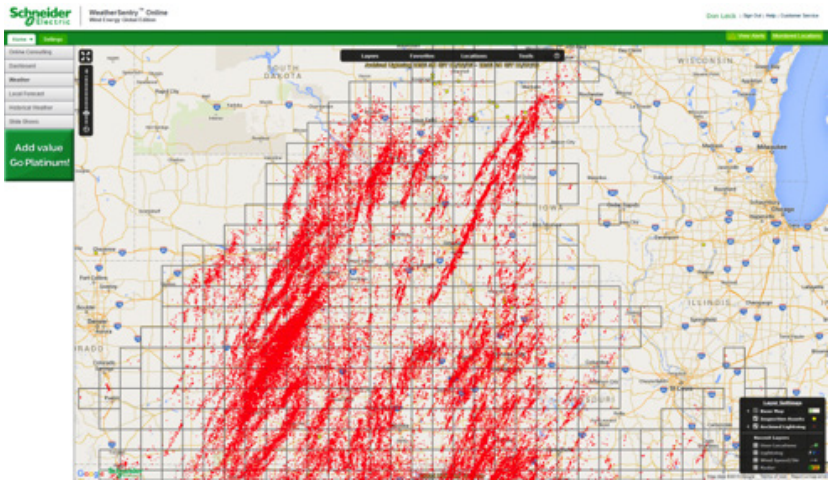


Figure 1: Lightning track data is aggregated, then it is illustrated through GIS-mapped asset overlays.

However, modern advances in weather technology have brought about more precise weather detections for wind-farm operators. After-action reports analyze the likelihood that turbines within a designated radius were struck by lightning, allowing wind-farm operators to better assess potential damage following a storm and conduct more efficient inspection and repair plans.

WHEN LIGHTNING STRIKES

Unrepaired damage to turbine machinery can intensify exponentially. Extensive stress is placed on the blades when operated. When a turbine is impaired without notice — often puncture-related — what may begin as a minuscule crack or fracture that can be easily fixed with minimum cost can expand into a massive and costly fix.

However, economic cost of repair is not the only consequence. Turbines kept from spinning due to lengthy periods looking for potential damage can reduce energy output. Loss of power generation can be avoided with more accurate damage assessments that translate into faster maintenance and repairs.

More efficient and effective assessments are constructed through GIS-mapped asset overlays with highly accurate lightning tracking data. The combination of lightning strike data and specific asset location enables accurate evaluations of potential damage.

WORKING FOR WIND FARMS

A catalog of every wind turbine and its specific location within a wind farm is listed. After a storm, this list of turbine coordinates is compared to the recorded latitude-longitude of the lightning strikes.

Operators are notified of the exact location lightning struck in proximity to a turbine, polarity (positive or negative) of the strike, and the intensity of the lightning when it crosses a certain locational threshold.

A new report is produced every 24 hours giving operators the

Figure 2: A catalog of every wind-turbine asset within a wind farm operation is indexed with its data.

Area - Asset	Distance(m)	Polarity	Amplitude	Date-Time	Latitude	Longitude
Conception-T03	315	-	16	2:36:05.5 AM CST 11/17/15	40.24603	-94.6797
Crosswinds-T03	182	-	80	12:28:32.2 AM CST 11/17/15	43.05408	-94.90556
Crosswinds-T04	290	-	28	12:29:40.1 AM CST 11/17/15	43.06365	-94.90011
Crosswinds-T05	26	-	116	12:29:40.1 AM CST 11/17/15	43.06604	-94.89814
Crosswinds-T05	332	-	28	12:29:40.1 AM CST 11/17/15	43.06365	-94.90011
Crosswinds-T09	21	-	38	12:34:11.5 AM CST 11/17/15	43.08468	-94.88329
Hardin-T01	38	-	14	1:59:12.0 AM CST 11/17/15	42.08263	-94.36556
Hardin-T02	339	-	36	2:07:24.0 AM CST 11/17/15	42.08465	-94.35599
Hardin-T03	25	-	36	2:07:24.0 AM CST 11/17/15	42.08465	-94.35599
Sleeping Bear-T21	299	-	20	11:36:13.8 PM CST 11/16/15	36.63667	-99.46755
Sleeping Bear-T21	306	-	10	11:36:13.8 PM CST 11/16/15	36.63685	-99.46746
Sleeping Bear-T22	7	-	10	11:36:13.8 PM CST 11/16/15	36.63685	-99.46746
Sleeping Bear-T22	29	-	20	11:36:13.8 PM CST 11/16/15	36.63667	-99.46755
Sleeping Bear-T35	95	-	4	11:25:37.3 PM CST 11/16/15	36.65079	-99.50849
Sleeping Bear-T36	343	-	4	11:25:37.3 PM CST 11/16/15	36.65079	-99.50849

ability to assess and prioritize a turbine-inspection-and-maintenance schedule for the day.

VALUE OF LIGHTNING DATA

While real-time lightning is tracked and reported, the data from the report is archived and available long after the lightning activity is over. That means wind farmers can study every lightning strike on their property from the day they sign up for the service. This feature helps wind farms track lightning activity near a turbine or to see specific locations in the wind farm which might be susceptible to lightning strikes. This archived information also is useful to identify patterns of lightning activity that might be useful when looking for locations to install new turbines to extend a wind farm.

LOOKING AHEAD

Wind-farm operators are not the sole beneficiaries of this asset-specific lightning threat assessment. The entire utility industry can take advantage of weather system services to create safer, faster, and more efficient response efforts to threat assessments of assets.

And, with the recent launch of Hub Height Winds forecasting capabilities, the energy industry will be able to identify potential risks of high wind speeds and wind gusts, as well as the impact they may have on assets.

The energy industry can now use predictive intelligence to plan ahead and improve reliability and decrease costs down the road. With increasing weather volatility and pressure on asset-management budgets, this capability is critical for understanding weather's impact on assets and how best to manage them.

Protecting the Blades

Leading-edge erosion can dig into a turbine's performance, but solutions exist to keep minor worries from becoming major problems.

By Santhosh Chandrabalan

Every year, wind-turbine blades face numerous environmental and weather challenges — including rain, hail, blowing sand, and salt spray — that can cause significant leading-edge erosion. Although small in size, these elements can lead to pitting, gouging, and delamination of the blade, severely affecting the entire wind turbine.

In addition to drastically compromising the integrity of the blade, leading-edge erosion also affects a turbine's overall aerodynamic efficiency. Remarkably, structural changes caused by even minor erosion can have a significant effect on annual energy production (AEP) and return on investment (ROI). In fact, recent studies have demonstrated that pitting and gouging can reduce AEP by approximately 4 to 10 percent, while delamination can reduce AEP by up to 20 percent.

Regardless of geographical location, blade height or length, leading-edge erosion is an issue that affects all wind turbines. So, it's imperative to proactively implement innovative solutions to address and mitigate the problem. Best practices for wind-turbine repair and maintenance include:

WIND PROTECTION TAPE

One of the most popular and trusted solutions for leading-edge erosion repair is wind-protection tape. Constructed with durable, abrasion-resistant polyurethane elastomers, this product originally was developed for the heavy-duty use of aircraft radomes and helicopter blades. After installation on a blade's leading edge, wind-protection tape shields the blade from erosion, puncturing, tearing, weathering, and water damage.

Wind-protection tapes and coating can extend the life of wind-turbine blades.

While coatings may be affected by external conditions, including humidity and temperature, tapes provide uniform thickness and finish, making it one of the most consistent and reliable products for a project.

It's important for OEMs to research a variety of wind-protection tapes to determine what material composition and application instructions will work best for each repair scenario. Special considerations also should be made to determine UV stability in warmer climates. Fortunately, due to recent innovations, many of the tapes on the market have been designed for simple application in the factory or in the field via rope or platform access, regardless of weather or terrain.

WIND BLADE PROTECTIVE COATINGS

Two-component polyurethane coatings are designed to help protect the leading edge of a wind-turbine blade from sand, rain, and other minimal impacts. Protective coatings are applied with either a brush or casting, and they provide excellent erosion protection in a single or multiple layer.

When deciding what application process to use, OEMs should consider that both tapes and coatings can extend the life of a blade by providing maximum turbine efficiency and reducing interruptions caused by service from maintenance and repair. Additionally, when selecting a wind-blade protection coating, attention should focus on a product that can easily be applied in both the factory and the field to ensure an efficient curing process.

Finally, it is also important to consider additional repair options, such as fillers, abrasives, and accessories, if the wind-turbine blade has signs

Leading-edge erosion can reduce AEP by up to 20 percent.

of previous damage. These tactics are typically used in concurrence with protective coatings to ensure a successful repair process.

WIND EPOXY AND POLYURETHANE FILLERS

If the wind blade has sustained damage past the point of protection and needs repair, epoxy or polyurethane (PU) fillers can be used to remedy surface damage.

When selecting epoxy or PU fillers, three crucial components should be considered: performance, time, and application methods. There are several options available that incorporate innovative cartridge and applicator systems, which ensure accurate mixing and reduce the possibility of error and waste.

As wind blades are designed to flex substantially during use, fillers need to be flexible, yet tough, to prevent any surface cracking. As fillers become the base of the leading edge, it's essential to select the correct filler, coating, or wind protection tape to avoid additional blade damage.

SURFACE BONDING APPLICATIONS

In addition to extending the life of a wind-turbine blade with preventative measures, there are several tools available to proactively optimize aerodynamic efficiency and AEP. These bonding and composite tools are used to secure aerodynamic attachments — including vortex generators — or bond composite wind blades. Depending on the project, several application solutions are available, including:

Acrylic Foam Tapes: Acrylic foam tapes provide an exceptional substitute to liquid adhesives and mechanical fasteners, due to their durability, ease of application, and ability to withstand residual forces including high UV rays and severe weather conditions. This product is typically used for applications when reliable bonding or sealing is required, and accommodates rigorous flexing and fatigue.

Wind Blade Bonding Adhesives: A two-part, structural epoxy adhesive for bonding composite wind-turbine blades, this high-performance, tough adhesive combines shear and peel strength along with excellent durability. Bonding adhesives also provide a faster cure speed, saving up to six hours of mold time per blade.

Structural Adhesives: Used for bonding composite wind-turbine blades and other general-purpose applications, this rigid adhesive combines high shear strength with excellent toughness and durability.

Dry Layup Adhesive: Dry layup adhesive is a sprayable, synthetic elastomer-based adhesive for bonding and holding glass fabrics and other reinforcements and materials (i.e. flow media) in place during the infusion process.

Surface bonding applications can be used to secure attachments to optimize efficiency.

CONCLUSION

In an effort to maximize ROI, OEMs must consistently research and identify the best solutions to reduce leading-edge erosion.

By implementing a proactive approach, individuals can address both prevention and repair through the correct use of fillers, protective coatings, tapes, and aerodynamic upgrades.

More importantly, a comprehensive approach to wind-turbine maintenance can lead to a sizeable increase in future earnings and AEP.

For more information about 3M Wind Energy, go to 3M.com/wind.

Advance Warning Advantage

Condition monitoring can maximize maintenance resources.

By Greg Ziegler

Before the next maintenance inspection for a wind turbine, much can happen. At every turn, critical components can be moving toward failure. Wind turbines are complex systems integrating thousands of components and will be buffeted by many of the same operational and maintenance issues associated with any machinery. And fixes to the systems can be costly in time, money, and wind-farm productivity.

When unplanned turbine downtime becomes unavoidable because an essential component has failed without warning, potentially sky-high costs can follow. Expensive cranes may have to be transported and mobilized on land or offshore to access the trouble spots; replacement parts will need to be sourced and delivered, and technicians may have to be redeployed from other essential tasks to handle the immediate problem.

With the reliability and productivity of wind turbines hanging in the balance, technologies to monitor and track deteriorating component conditions in real time have gained considerable interest and applications. When the market was still in its relative infancy, condition-monitoring systems specifically engineered for turbines were few and far between. Today, as the industry has begun to mature in various regions, most new turbines will be equipped with some level of monitoring system to keep turbine health current.

SKF

When a wind turbine fails, on-site technicians likely will be the first responders. Advance warning can make a substantial difference in keeping turbines productive and operating reliably.

But for unmonitored installations, performance can go awry with little or no advance notice. With the typical 20-year service life for the average wind turbine, it is not a question of "if" but "when" maintenance attention will be required. Proactive monitoring of critical wind-turbine components can eliminate many of the unknowns, while unlocking optimized capacity and long-term profitability on the wind farm.

TURNING TO COMPONENTS

Most large, modern wind turbines are horizontal-axis types. Their primary components include blades or rotors (which convert the energy in the wind to rotational-shaft energy), drive train (usually including a gearbox and generator), tower (support structure for the rotor and drive train), and other equipment, including controls, electrical cables, ground support, and interconnection equipment.

When a wind turbine fails, on-site technicians likely will be the first responders. However, the resolution to remedy the failure will vary by installation. Operators may rely upon OEMs, independent repair and maintenance contractors, their own in-house technicians, or a combination. Local distributors will be enlisted to supply components for out-of-warranty repair.

Advance warning can make a substantial difference in keeping turbines productive and operating reliably, while promoting timely maintenance practices in the process. Successfully transferred from applications in other industries, condition-monitoring systems (CMS) enable early detection and diagnosis of potential component failures and serve as a platform for implementing condition-based maintenance (CBM) practices. CMS also can detect wind-turbine problems from causes other than component failure, such as rotor imbalance due to icing and electrical faults.

DETECTING PROBLEMS

Condition monitoring is a strategy whereby physical parameters (including vibration, temperature, lubrication particles, and others) are measured regularly to determine equipment condition. This process makes it possible to detect machine and component problems before they can lead to unexpected downtime and unplanned costs from maintenance and lost production.

An online condition-monitoring system offers a powerful tool for managing day-to-day maintenance routines and can include the capability to review data remotely.

An online condition-monitoring system offers a powerful tool for managing day-to-day maintenance routines inside a wind turbine and consolidating risky, costly maintenance activities. By equipping operators to monitor and track deteriorating component conditions around-the-clock in real-time, expedient maintenance decisions can be based on actual machine conditions instead of arbitrary maintenance schedules. Mounted sensors and related software do the work and pinpoint the problems. Along the way, costs can be saved and unscheduled downtime can be minimized.

The principles of condition monitoring are not new, but the proactive approach has gained significant ground in the industry due to the increasingly sophisticated computational interpretation and analysis capabilities for measured data. CMS data can be applied to adjust scheduled maintenance intervals and strike an ideal balance between the cost of maintenance and the cost of unscheduled fault repairs.

In addition, monitoring systems can enhance and optimize maintenance forecasting by continuously recalculating fault frequencies and delivering accurate values based on reliable trends. This can facilitate the assigning of alarms at various speeds and loads, including low main shaft speeds, and form the basis for trend-based root-cause failure analysis.

Most monitoring systems can accommodate a large population of turbines and multiple data points. Using vibration sensors mounted on a turbine's main shaft bearings, gearbox, and generator, systems (in tandem with software) will continuously monitor and track a wide range of operating conditions for analysis.

Wireless capabilities expand system potential by offering a way to review data remotely from any location with a computer or hand-held device with internet access. This can shorten lead-time from alarm to solution.

EVALUATING CONDITIONS

Operating conditions that can be targeted for early detection, diagnosis, and remedial action include:

- Unbalanced turbine blades
- Misalignment
- Shaft deflections
- Mechanical looseness
- Foundation weakness
- Bearing condition
- Gear damage
- Generator rotor/stator problems
- Resonance problems
- Tower vibrations
- Blade vibrations
- Electrical problems
- Improper or inadequate lubrication

An example of one of the more comprehensive condition-monitoring systems in use at many installations around the world illustrates the advantages.

This particular system is grounded in an "intelligent" monitoring unit, which is mounted inside the turbine's nacelle. The unit features 16 different channels where multiple measurement points can be connected. A typical wind-turbine configuration would incorporate the main bearing (one channel), gearbox (four channels), generator (two channels), and tachometer (one channel). In addition, other monitoring points can be added, including tower/structure vibration, blade vibration, oil temperature, oil pressure, oil quality, and generator temperature.

This system applies built-in hardware auto-diagnostics, which continuously check all sensors, cabling, and electronics for any faults, signal interruption, shorts, or power failures. Any malfunction triggers an alarm.

Such a system even allows operators to use the information to control or postpone repairs, as one SKF customer discovered.

In this customer's case, a monitoring unit was eventually installed on a wind turbine that had been experiencing consistent damage to the low-speed part of its gearbox. After installation, the monitoring system performed as intended and beyond. The system not only registered the damage, but also determined the damage was stable enough to postpone the gearbox replacement and keep the damaged turbine in operation.

After monitoring the damaged part for almost 12 months, the system eventually detected a rapid increase in the damage pattern, and only then was the turbine taken offline for gearbox replacement. By postponing the gearbox replacement for a year, the wind farm was able to generate interest on the capital needed for the overhaul and efficiently plan for parts delivery, shipping, personnel, and cranes for the job.

The alternative would have been a rushed operation accompanied by unnecessary costs, several weeks of downtime, and lost productivity.

EVOLVING TECHNOLOGY

By tracking component health and evaluating data from monitoring, maintenance activities can be coordinated across the wind farm, service calls can be better planned and bundled, and operators can take advantage of planned shutdowns to service several turbines at the same time, since machinery conditions will be known from the monitoring.

A viable condition monitoring system ultimately can assist wind-farm operators in performing appropriate inspections, maintenance activities, and fixes at the right time when and where needed, regardless of the calendar. As a result, wind-farm operators can extend maintenance intervals, consolidate maintenance initiatives, cut operating costs and costs per kWh, reduce the risk of unplanned shutdowns, prevent lost energy production due to breakdowns, and predict remaining service life by turbine. All contribute economies and efficiencies for a wind-farm operation.

The monitoring process for a wind turbine can effectively reduce lifecycle costs and extend service life. Implementing necessary repairs when problems begin to surface, for example, proves easier and much less expensive than running a turbine to catastrophic failure.

Looking ahead, significant research and development is under way involving condition monitoring techniques, fault analysis, and optimized maintenance procedures. The evolving technology intends to help keep operating and maintenance costs to modest levels and contribute overall toward the cost-effectiveness of wind-turbine technology.

The evolution is further continuing with a focus on ergonomics and improved diagnostics and prognostics. And technician requirements may change for the better with advances in technology, leading to improvements in the scheduling and deployment of manpower.

Above all, support is readily available. One of the best practices in navigating the challenges of wind-farm operations and maintenance is to partner with an established services provider experienced in the many interrelated aspects of wind-turbine technology. This will inform operators with the most current engineering resources to help keep the blades turning productively.

For more information, go to www.skfusa.com

PROFILE

LM Wind Power

What began as a vision has sparked LM Wind Power to implement a greener future while pushing the cutting edge of turbine-blade technology.

By Kenneth Carter

LM Wind Power is not content with just supplying wind-turbine blades to make the world's energy supply greener and cleaner.

It wants to make the process that manufactures those blades cleaner as well.

"We are proud of our contribution to a cleaner world, but also we recognize that the manufacturing process comes with a footprint, and we are determined to become leaner, greener, and cleaner throughout our operations," said Christopher Springham, vice president of Communications, Human Resources, and Sustainability.

LM Wind Power has been making turbine blades since 1978, and with wind's future still going strong, the company continues to make big strides in the industry.

And those big strides are quite literal.

WORLD'S LONGEST BLADE

In June, the company broke the record for the world's longest blade at 88.4 meters.

The component was designed for Adwen's AD 8-180 wind-turbine model, with 8 MW nominal capacity and a 180-meter rotor diameter.

The first of these massive blades was manufactured at LM Wind Power's Pilot Plant in Lunderskov, Denmark. Later, it was transported to a facility in Aalborg for testing.

The world's longest blade is transported from Lunderskov to Aalborg, Denmark. At 88.4 meters, the blade was perhaps the largest cargo ever transported on Danish roads.

"Creating a blade on this scale presents a large step towards lowering the cost of energy from offshore wind," Springham said.

LM Wind Power has a history of breaking size records. The LM 61.5 P was the world's first blade to surpass the 60-meter mark in 2004. It was followed by the LM 73.5 in 2011.

The LM 88.4 P dwarves these blades by comparison — in fact, the LM 73.5 P could easily fit inside it, according to Springham.

LM Wind Power is a pioneer in offshore wind with a proven track record that dates back to the early offshore wind projects.

LM Wind Power

Founded:
1940; became LM Wind Power in 2010

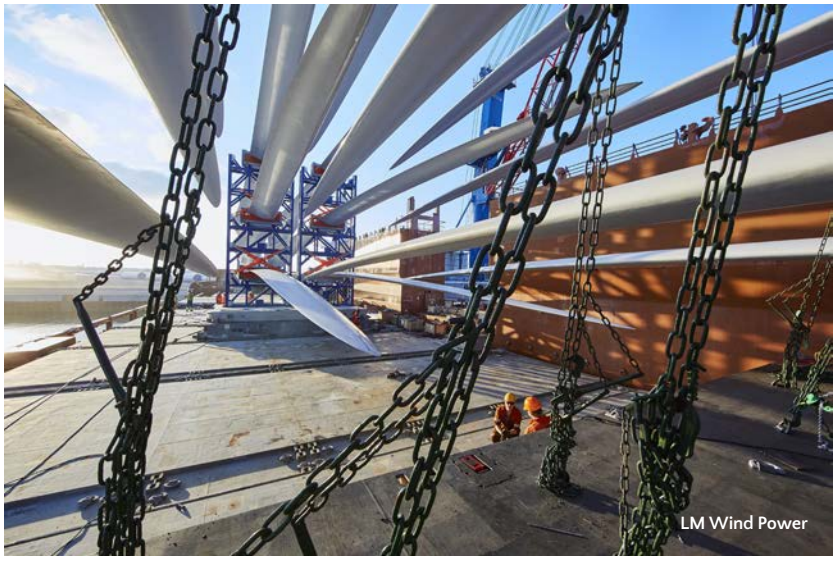
Headquarters:
Kolding, Denmark

Website:
www.lmwindpower.com

Recently, it has had a hand in the construction of the Block Island Wind Farm off the coast of Rhode Island, the first offshore wind facility in the U.S.

The wind farm will be powered by 15 LM 73.5-meter blades, manufactured by LM Wind Power for GE's 6 MW Haliade turbine.

LM 73.5-meter blades are shipped from Esbjerg, Denmark, to Block Island off the coast of Rhode Island to power the first offshore wind farm in the U.S.



Blades are prepared for transport at LM Wind Power's plant in Goleniow, Poland.

DESIGN CHALLENGES

LM Wind Power's fundamental blade constant — two fiberglass shells attached to rigid webs — has not changed since it began producing blades almost 40 years ago.

"For our new generation of blades, finding the perfect balance between aerodynamics and structure presents the greatest design challenge for each blade type," Springham said.

Aerodynamic properties are crucial in determining how well a blade can extract energy from the wind. LM Wind Power has developed considerable expertise in calculating blade geometry and optimizing performance, according to Springham. The structure defines the modular units of the blade that are assembled to provide maximum strength and rigidity without adding too much weight. These blades are then produced all over the world, enabled by LM Wind Power's high-quality, global-manufacturing footprint.

"Our wind-turbine blades are advanced creations: designed, manufactured, and validated with cutting-edge tools to ensure they can endure the forces of nature for more than 20 years," Springham said. "We constantly work on new technologies to both enhance performance and push the limits on wind-farm location."

INNOVATIVE IDEAS

LM Wind Power achieves this with innovation, deeply embedded in the company's DNA.

With that in mind, the company has developed many patents that have allowed it to push the cutting edge of blade technology.

"We received our first patent way back in 1968 for a special conveyor used to transfer live fish into a lorry," Springham said. "This history of innovation continues today. Since beginning to develop wind-turbine blades in 1978, we have patented more than 250 inventions."

In addition to new blade types, LM Wind Power also introduced new technologies to enhance Annual Energy Production, reduce noise, and improve blade reliability. Most of its current patents deal with lightning protection, blade aerodynamics, blade and rotor design, production technology, blade monitoring systems, service and inspection systems, and logistics.

"PRE-BEND" TECHNOLOGY

One of LM Wind Power's well-known and visible patents is the blade "pre-bend" — a design characteristic that distinguishes LM blades, according to Springham.

Some blade manufacturers develop

LM Wind Power's Rain Erosion Test Center in Denmark. The Rain Erosion Test Center tests the endurance of protective coatings on a fiberglass specimen shaped like a blade leading edge. Three whirling arms rotate at high speeds under an artificially generated rain field, with a rotational speed of 145 to 398 miles per hour.

straight-and-stiff blades in order to avoid tower strikes in heavy winds. By pre-bending blades, LM Wind Power can build blades that are already bendable and a little less stiff than other blade models. This allows for savings on the cost of materials to build the blade and ultimately contributes to reducing the cost of wind energy.

"The cost of wind energy has reduced by 10 percent every decade since we began manufacturing wind-turbine blades," Springham said. "Today, we are focused on one goal: ensuring that we achieve cost parity with all forms of energy — including renewables, oil, gas, and nuclear — without subsidy and in the most sustainable way possible. We have already reached this crucial point in certain wind markets with certain products, and together with our customers and suppliers, we innovate constantly to drive costs down still further."

LM Wind Power is constantly working on new technologies to enhance performance and push the limits on wind farms. Some examples include the SafeReceptor Insulated Lightning Protection System, high performance leading-edge protection, advanced monitoring systems, de-icing and aerodynamic add-on features, and many more products in the pipeline, according to Springham.

Many innovations originate in LM Wind Power's global R&D centers in Denmark, the Netherlands, and India staffed by more than 240 engineers, but that innovation is not limited to products, Springham said.

"Innovation for us is holistic, but with a firm focus on making wind compelling, competitive, and cost effective," he said.

The LM 88.4 P, the world's longest turbine blade, sits inside LM Wind Power's Pilot Plant in Lunderskov, Denmark.

THE BEGINNING

And it all started with a business that had nothing to do with wind.

LM Wind Power began life in 1940 as Lunderskov Møbelfabrik (which translates into Lunderskov Furniture Factory). It was founded by Ejner Lorentzen and Aage Skouboe as a wooden furniture factory in the small town of Lunderskov, Denmark.

Not soon after, the founders began to experiment with fiberglass in the early 1950s.

In 1953, Lunderskov Møbelfabrik divided into LM Camping and LM Glasfiber. Lorentzen was in charge of LM Camping, and Aage Skouboe led LM Glasfiber. The two divisions

LM 42.1 blades powering a wind farm in Spain.

LM 42.1 blades powering a wind farm in Spain.

collaborated to create LM Caravans, which combined a fiberglass exterior with solid carpentry work in the interior. Out of the 300 caravans built, some are still being used today, according to Springham.

During that time, LM Glasfiber primarily focused on fiberglass boats, while also marketing a variety of other fiberglass items. For example, LM fish boxes were used to transport live fish by truck instead of in wooden barrels by train. A small production of speedboats began in 1954, followed by minor leisure boats and, finally, the production of the well-known LM sailboats in 1969. The LM 27 became Europe's most-produced motor sailor at the time.

MOVING INTO WIND

With this intrinsic knowledge of advanced materials and a hard-earned understanding of the principles of wind energy, LM Wind Power became a market leader in wind-turbine blades. Soon after 2000, Doughty Hanson, a European private equity firm, supported the continued expansion of the company's global manufacturing footprint.

The company officially became LM Wind Power in 2010.

"We chose to retain our initials as a tribute to our rich legacy as LM Glasfiber, but also as a gentle reminder of where we began," Springham said. "Wind power is what we deliver, and our name represents that contribution."

Wind remains one of the most economically attractive forms of renewable energy for large-scale electricity generation. It is expected to develop even further as offshore opportunities become a key growth segment as traditional markets stabilize.

"We are confident that the future is bright for LM Wind Power and the wind industry," Springham said.

Following a strong performance in 2015, LM Wind Power is committed to capitalizing on the strong demand for its products, while further reducing the cost of wind energy.

"In doing so, we will further drive the top-line and improve the bottom-line result," Springham said. "A revised corporate strategy is already in place which clearly defines our path to achieve that success in the future."

LM Wind Power wants to reduce the cost of wind energy in order to serve the whole global economy, but ultimately, that goal represents the chance to light up the world for the 1.3 billion people who don't have access to clean, affordable electricity.

"We believe that as we succeed, we will, quite literally, change their world for the better," Springham said.

CONVERSATION

Edward Wagner

Chief Digital Officer
Sentient Science Corporation

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What are your duties with Sentient Science?

I'm the chief digital officer responsible for turning our customers' hard assets like wind turbines into DigitalClone models that we can run computational tests on and ultimately make money for our customers from the data coming off those machines. We don't only work with operators, though. We do the same for the gearbox, component, and lubrication suppliers that want to serve the operator base, as we calculate the components and services needed over time to extend asset life. I am responsible for engaging the operators and suppliers in a new digital business model to lower the cost of O&M.

Tell us about Sentient Science and its core philosophy.

Sentient Science's goal is to help operators lower their operations and maintenance costs, to reduce the risk of failure of their assets and ultimately lower the cost of energy through the life extension of operator assets.

Sentient does this by applying a material science-based approach to machine failure developed under DoD contracts for the world's largest operators — Army, Navy, Airforce — in an initiative to lower their cost of service. We applied these learnings under request by DoE to wind-turbine gearboxes. The rest is history. We now have 18,000 assets under contract and expect to get to 50,000 assets within those existing customers.

What are the problems with standard diagnostics vs. advanced prognostics?

What business problem do you want to solve? If you want better planning of your O&M budgets over 18 months, or if you want to extend the life of your assets, you need the forward visibility from advanced prognostics. We see things that sensors will never see, and we can alert the operator when we see problems occurring in bearings and gears before anyone thought possible. This gives us the ability to affect inventory carrying costs and lower warranty costs. We provide the foresight needed for better financing for new development, for negotiating better T&Cs, and insight into alternative supplier options. These are not the problems that can be solved with diagnostics.

Sentient Science has developed DigitalClone to help better predict failure rates. How does DigitalClone work?

We look closely at the overall system, the gearbox, and the critical components within the system, bearings, and gears. Our system simulations provide a list of critical components from worst to best. At that point, we take a deep dive into those components to look at their material properties, the metals used by the supplier, the loading conditions on that component for each specific asset, and the potential impact of component failure on surrounding components. We generate the lifing predictions for the components and the gearbox. Now, we have the information to make an action list: What components should be replaced up-tower? What assets should be de-rated to avoid damage propagation? What assets need gearbox exchanges, where and when? This is all provided within a SaaS, but we work closely with our operators to look at the data, correlate it against other input they have, and finally to provide the business decisions to extend the asset, site, or fleet life.

How do you create a predictive model for critical component failure?

We build a DigitalClone model of the asset and its critical components that

we want to simulate and affect. That model is based on 13 years of research and development, $25 million in investment and validation tests to prove our approach. It's a computational systems and component-computational model that looks at rotating components, material quality, tribological effects, and design variables. We run our models using 8,000 processors to simulate remaining useful life. The model is loaded with the operating conditions of the individual machine that we're trying to affect. We take the SCADA, the wind loads, the maintenance history, and what we know of the bill of materials and run individual simulations for each individual gearbox. It's a lot of processing we throw at a fleet of wind turbines to assess remaining life and the options to extend life. This is new for the wind industry but not new for the defense and aerospace industries.

What are the advantages of the "Buy on Life" feature in DigitalClone?

Imagine you knew the real life of a component, not the supplier assessment, but the actual life as calculated in your individual asset. That means you could make strategic choices between supplier offerings based on life and price of the components. It could enable you to move to a new "Power by the Hour" business model or lead you to plan your supply and inventory management differently.

Today, operators buy on price based on the components the OEM recommends. But what if that component has a shorter life? It might have failed prematurely, and you replace it with the same component. The outcomes will be the same.

Many of the critical components in today's fleet have been designed and installed 10 years back with older modeled components. There may have been improvements in the component offerings from your current suppliers. The Buy on Life feature allows you to simulate how the different offerings would affect the life of the asset and make strategic decisions based on that.

You can compare components and suppliers and buy based on asset management and extended asset life.

Explain what "automation" is and how it works with the wind industry.

Simply put, we create a forecast of actions to extend the life of wind assets including the ROI for each action. That forecast includes both up-tower and down-tower actions, operational changes and GBX changes, where it's located, and when it will fail. For the first time, operators now have multi-year forecasts by asset including the component-replacement schedule needed to minimize gearbox replacements and to extend life.

Now with that information, we've built a supplier portal where operators can automatically push that information to their approved suppliers. The operators can disclose as much or as little information to the suppliers as they want — including multiyear requirements — in order to negotiate the best terms possible. The supplier can drop-ship inventory where and when it's needed instead of storing inventory and tying up capital.

This level of supply-chain automation is proven in other industries. Now we're bringing that automation and effectiveness into the wind markets in order to lower the cost of energy specifically by improving supply and inventory-chain automation.

How does automation reduce energy costs?

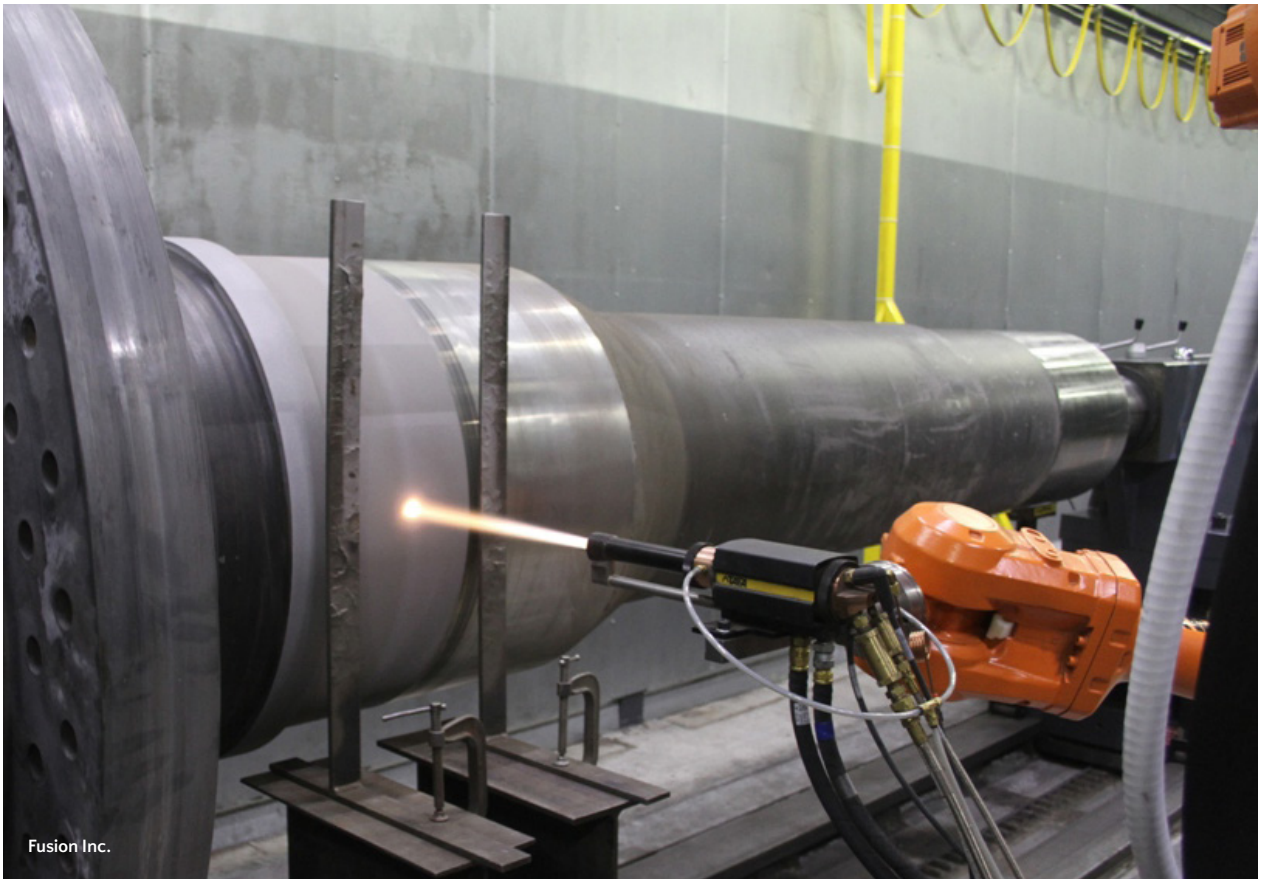
O&M efficiencies can be taken directly to the bottom line or to new investments. The problem has been variable O&M costs causing unbalanced pro formas. The variable costs of O&M are eating away at the slim profit margins many operators live by. However, by lowering the risk of failure and gaining a better understanding of asset life, operators can now plan for fewer gearbox replacements and extend asset life beyond 20 years. We've seen examples of repowering, gearbox-life extension, component and supplier optimization, new additives, and lubrications all simulated with Sentient's DigitalClone Live system, so that operators have the information they need to make the best financial decisions possible.

Our goal as a company is to significantly reduce the cost-of-energy equation by looking at all areas of the organization that would benefit from knowing more about their assets, not just operational and asset management, but new development, business strategy, and risk management. It's a goal and a long road for us. But the savings will either allow our customers to hedge against the PTC or to take that savings as a direct reduction in energy cost.

What future developments are in the works at Sentient Science that will be beneficial to the wind-power industry?

By knowing future failure rates, we're now powering other business decisions made by the operator including risk management, new development, and supply-chain automation. What started as a pure O&M benefit is clearly affecting other areas of the company, so we can achieve our goal for reduced cost of energy. What you'll see from Sentient now is more automation covering the full asset and more applications providing asset health information to other areas in the organization. I expect we'll get to 50,000 assets under contract soon, so it will be exciting to see what happens.

New Coating Booth Reduces Lead Times for Extra-Large Parts



Fusion Inc.'s new coating booth can handle customer components up to 96 inches in diameter and 28 feet long and up to 80,000 pounds.

Fusion Inc. in Houston has just completed its largest, state-of-the-art coating booth to help make the coating of larger components a less arduous process.

Coatings are used to help components survive harsh service conditions, which can greatly increase service life. Many OEMs protect their new components by coating them with different carbide and super alloys so as to extend their service life.

The new coating booth, however, is sound proof and equipped with a dust-collector.

It can handle customer components up to 96 inches in diameter and 28 feet long and up to 80,000 pounds. The booth itself is 16-feet-wide by 13-feet-high by 51-feet-long.

The roof opens hydraulically, so an overhead crane can be used for loading and unloading. The booth has a gantry-supported robot, which can be programmed in detail for any areas in need of coating.

It also incorporates the latest LED lighting and interior cameras, so customers can log on and view their individual components being coated in real time.

One of the more innovative features of the booth is its ability to robotically coat large crankshaft rod journals. This is the first coating booth with this capability.

Crankshafts have connecting rod journals that are off-center on "stroke." The robot is able to follow the stroke of the crankshaft, so it can be coated.

The booth was the idea and creation of Stratton Gillis along with engineers Bob Curd and Paul Curfman with the help of intern Reese Chesnut. Reese is attending Mississippi State University pursuing a mechanical-engineering degree.

Fusion also has added a tug and two large capacity

transfer cars to safely move large, heavy components to-and-from the blasting room to the booth.

Fusion Inc. started in 1959 as Ceramic Coating Inc. and has been a leader in the development of thermal spray applications and finishing for 57 years. The company specializes in the repair of downhole components, wind-turbine main shafts, and rotating/reciprocating components including large industrial crankshafts. Fusion offers High-Velocity Oxy-Fuel (HVOF), Twin Arc, and Plasma coatings along with finishing capacities up to 96 inches in diameter by 37 feet in length and 80,000 pounds.

Coating is not new for the wind industry. Fusion has sprayed main shafts using the HVOF process since 2010. But Fusion has seen a growing trend for larger main shafts for wind turbines. Fusion now can accommodate 96 inches by 28 feet in the coating booth and 96 inches by 37 feet in its largest grinder.

Source: Fusion Inc.

For more information, go to www.FusionHouston.com

Trailer Provides Maximum Flexibility for Hauling Oversized Equipment

For more than a decade, Talbert Manufacturing, a North American leader in specialized heavy-haul solutions, has manufactured its 55CC close-coupled lowbed trailer. The trailer features a low deck height, high capacity rating and a removable gooseneck, allowing safe and easy loading of oversized equipment, including excavators and dozers.

"Our 55CC is our most popular, best-in-class lowbed trailer," said Troy Geisler, Talbert Manufacturing vice president of sales and marketing. "This trailer's features maximize operator versatility, which makes it an ideal addition to virtually any equipment fleet. The innovative design continues to provide a durable, safe choice for equipment movers."

The trailer features Talbert's industry-leading 18-inch loaded deck height — two inches lower than competitive versions — and a 6-inch ground clearance for easy navigation of oversized loads under bridges and through tunnels without the need for rerouting.

The trailer's rear deck and bridge section feature the widest bucket-well arrangement in the industry, allowing for maximum space to lower the excavator bucket and stick. The recessed boom well's design coupled with the deck's low bucket-well maximizes space for positioning the excavator's bucket and stick. The design provides excavator transport with the lowest possible overall height.

The trailer's 26-foot deck has a capacity rating for half the deck length, allowing operators to haul 55 tons in 13 feet. Most competitive models require distributing that weight across the entire length of the deck. Talbert's solution provides an advantage for concentrated loads, such as excavators and loaders. Connections for a close-coupled, pin-on fourth axle provide further distribution of the payload, when required.

The 55CC features Talbert's innovative four-cylinder removable hydraulic gooseneck that maximizes lift capacity and load height. While most conventional trailers feature only two or three cylinders that run perpendicular to the deck, Talbert was the first in the industry to engineer the non-ground engaging hydraulic gooseneck with four cylinders that run parallel. In addition to stronger lifting capacity, this means Talbert trailers minimize the need for frequent load adjustments. The trailer's 108-inch swing radius allows haulers to distribute the weight from the drive axles to the steer axle of the tractor.

Talbert Manufacturing's 55CC lowbed trailer features an industry-leading 18-inch deck height along with a high-capacity, 26-foot-long deck for easy hauling of large equipment while ensuring maximum clearance under bridges and through tunnels.

Talbert Manufacturing

Talbert constructs its main beams and side beams using a 12-inch deep I-beam fabricated from high-strength T1 steel with a minimum yield strength of 100,000 psi. The 2-inch Apitong flooring provides high strength for long-term durability under heavy loads. Other standard features include removable outriggers, a manual exhaust valve, recessed load-bearing bolsters, and a 12-volt LED sealed light system.

The 55CC trailer comes standard with six tie-down rings on each side of the deck and eight tie-down rings between the deck's main beams. Two sections of expanded metal baskets are mounted under the center of the deck to store chain and other items required for the job.

Talbert trailers come standard with Valspar R-Cure® 800 paint to prevent corrosion. For additional protection from the elements, customers have the option to upgrade the primer from alkyd to a zinc-rich primer or Valspar's.

Talbert has been building world-class heavy-haul and specialized trailers to rigorous customer specifications since 1938. The company offers complete lines of heavy-haul trailers and specialized transportation equipment for the commercial, industrial, military, and government sectors. Its trailers and equipment are used in applications as diverse as renewable energy, aerospace, heavy construction, in-plant material handling, manufacturing, and processing systems and much more.

Source: Talbert Manufacturing

For more information,
go to www.talbertmfg.com

CSZ Electromagnetic Actuated Clutches Have Zero-Backlash Design

Miki Pulley's CSZ Electromagnetic Actuated Clutches are for direct sale to OEMs in North America.

These CSZ Clutches have zero-backlash design. They use the magnetic force generated by the energized coil that provides engagement of input and output members of the clutch. They provide an efficient connection between a motor and a load with low inertia, minimal drag and zero backlash.

Miki Pulley CSZ Clutches feature an integrated bearing design that makes mounting fast and easy while ensuring application concentricity and excellent system runout. CSZ Clutches operate well in temperatures from 14 degrees F to 104 degrees F (minus-10 degrees C to 40 degrees C).

They are available in bores ranging from 10mm to 15mm, with

Miki Pulley CSZ Clutches have zero-backlash design.

Miki Pulley

brake torques ranging from 1.77 foot-pounds to 7.376 foot-pounds (2.4 Nm to 10 Nm). The CSZ uses corrosion-resistant materials and is RoHS compliant.

"Miki Pulley's CSZ Clutches are a great choice for high performance printing, paper processing, packaging, food processing and textile manufacturing systems," said Jon Davidson, Miki Pulley sales specialist. "They are proven performers in system applications around the world."

Source: Miki Pulley

For more information, go to www.mikipulley-us.com

Trelleborg Launches New Boat Landing Systems Maintenance Service

Trelleborg's engineered products operation has launched a new maintenance service for Boat Landing Systems (BLS). The new service is designed to identify degradation in BLS performance before it has the potential to cause damage to an offshore platform and a berthing vessel's structural integrity, which can result in huge costs and downtime.

Often used for projects in remote locations, it's imperative that a BLS is robust and reliable. Trelleborg's new maintenance service includes an annual survey designed to check the BLS for cracks on the rubber surface, de-bonding, permanent deformation, and corrosion. With this analysis, Trelleborg can identify degradation in performance before it can become a problem for the platform.

"BLS come under general inspection during routine maintenance schedules of the entire platform, a task that is usually carried out by a maintenance contractor," said J.P. Chia, engineering manager within Trelleborg's engineered products operation. "However, if not surveyed accurately, cracks on the rubber surface of the Eccentric Bumper Ring (EBR), de-bonding of the rubber and pipe, deformation, and/or corrosion can go undetected, potentially resulting in costly remedial repair and even replacement of the BLS."

"Offshore platform operators and contractors can reduce the degradation risks often associated with boat landing systems by working directly with an experienced product manufacturer," Chia said. "By doing this, contractors and operators can be sure the BLS in situ is reliable, tailored to the demands they are likely to face, and importantly, perform for the long-term. After all, no one knows the product like a manufacturer."

Trelleborg's boat landing system on site.

Trelleborg's engineers will conduct the BLS maintenance survey on an annual basis to identify areas of weakness and potential wear-and-tear. From best practice design, manufacture and testing, to full in-life support, Trelleborg can help establish and implement a best practice maintenance regime tailored to BLS requirements. Trelleborg offers in-depth understanding about the product, ensuring that extra eye for detail, ideal during maintenance surveys. In addition, should the product need to be repaired or replaced, Trelleborg can supply the most suitable solution on a project-by-project basis.

Trelleborg's engineered products operation designs, manufactures, and tests its BLS to the highest of standards. Based in the company's laboratory for full-scale research and development is its test press — the largest in the world of its type, with a load capacity of 18,300 metric tons and weighing in at 600 tons.

Additionally, Trelleborg formulates unique polymers for each project's shock cells in-house. Total transparency and an unrivaled understanding of materials technology is integral to every product.

Source: Trelleborg

For more information, go to trelleborg.tecs1.com/boatlandingsystems

INNOVATION

Research & Development • Design & Engineering • Forecasting & Analysis
Consultancy • Certification & Standards • Efficiency • Emerging Technologies

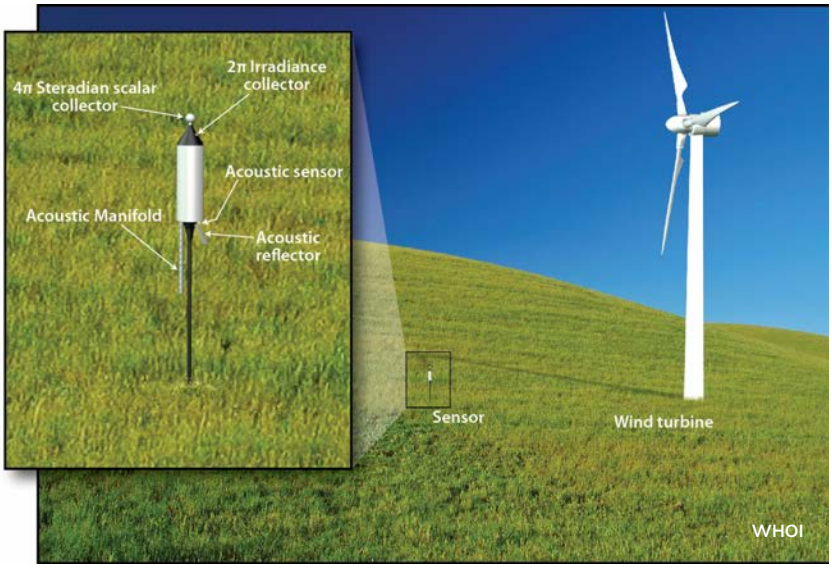
Innovative Wind Turbine Monitor Developed

The Woods Hole Oceanographic Institution has received a patent for its self-regulating terrestrial turbine control through environmental sensing.

Wind energy is a widespread clean alternative to energy from fossil fuels. The increasing number of wind-turbine installations highlights the need for comprehensive consistent environmental data, and the ability to instantaneously regulate the operation of wind turbines in response to immediate changes in environmental conditions from both external sources and the turbine itself.

The Multimodal Environmental Impact Monitor, or MIME, developed by engineers at The Woods Hole Oceanographic Institution (WHOI), uses an all-in-one sensor package that measures flicker, acoustic noise, and vibration generated by wind turbines. Alone or in combination, data from these modalities can provide input for turbine-control paradigms in order to optimize turbine operations and/or maximize energy production.

Turbine-performance management as well as site- and environmental-impact assessments for wind-turbine developments, are hampered by lack of available weather-tolerant instrumentation and inadequate sensors. Th s, appropriate long-term series assessments are not made, environmental- and human-health impact is not accurately determined, and output is not optimized.



MIME Wind Turbine Sensor.

"Current models for blade-shadow flicker don't take into account surrounding reflectors or structures, only topography and sun placement, and such estimates may be inaccurate," said WHOI Senior Engineer & MIME Inventor Paul Fucile.

Fucile also notes that measurement of turbine infrasound generation has become an area of interest in recent years — particularly because of its potential health effects on those living in close proximity — and is something that MIME measures with great accuracy.

Accurately determining the environmental impact and site suitability for new turbine installations allows for responsible planning and building and also allows developers to establish an accurate pre-installation baseline.

MIME is intended for permanent installation at turbine sites for persistent observation with the option for turbine control, or it can be placed on a tripod for short-term studies of multiple sites. It's designed for ease of use.

"The goal is to provide something that is affordable and user-friendly," Fucile said.

Source: The Woods Hole Oceanographic Institution

For more information, go to www.whoi.edu

System Monitors Motion and Impact of Offshore Vessels

UK Electronic Solutions (part of NSSLGlobal Group), has created a new self-contained motion and impact monitoring system suited to offshore vessels.

The system, Oceanic Dynamics, protects the longevity of offshore assets by monitoring and reporting vessel impact on structures, passenger comfort, and safety and engine performance and reliability.

Offshore structures have highly stringent requirements when it comes to the total impact force allowed from docking vessels. Vessels are generally obliged to remain within pre-specified ranges of impact force and to operate only within certain environmental conditions, or else run the risk of voiding their

service-level agreements. It is advantageous for companies operating vessels to closely monitor impacts that occur while docking and offloading in order to justify their performance. Oceanic Dynamics uses a microelectromechanical-system-based orientation sensor to monitor motion and impact of the vessel as it docks, enabling vessel operators to keep in line with regulations.

While impact monitoring was the starting point and primary function of the system, Oceanic Dynamics also is able to monitor fuel efficiency, engine data, and route information, as well as the vessel's dynamic stability within the water. These extra functions offer transfer vessel operators the potential to justify the cost efficiencies and eco credentials of their service. Oceanic Dynamics also employs an HD CCTV bullet camera to record footage from the deck of the vessel at all times. The video footage helps clarify events on board and provides further visibility when the vessel docks.

"We are currently (testing) Oceanic Dynamics and have installed the system on our newest crew transfer vessel, Dalby Ouse," said Steve Bartram, operations manager of Dalby Offshore. "So far, we are extremely impressed with the results and have already seen real value in our investment, particularly as it helps us comply with the impact force and contractual regulations required by the client. The fact that the product is available on a contractual basis is also cost-eff ctive and convenient."

"Offshore structures are reasonably sensitive to impact, and there are limits to the amount of force vessels can exert on them while docking or working alongside them," said Paul Rutherford, managing director of UK Electronic Solutions. "Oceanic Dynamics is the first system of this type to address the complete requirement of operators and construction companies. Although Oceanic Dynamics was primarily developed to assist crew transfer vessels, it can also be installed on tugs, pilot vessels, and lifeboats where it similarly monitors performance and provides an audit trail for incidents, maintenance, and performance."

Oceanic Dynamics delivers a weekly comprehensive report of how the vessel, crew, and environment are affecting vessel performance. This report can be tailored in-line with the specific content, complexity, and frequency required by the vessel operator. All information is stored locally within the unit until the vessel is within GSM or Wi-Fi range and can then be downloaded to shore. Should there be a requirement for data to be transferred to shore more immediately, the unit also is capable of integrating with any onboard satcom system.

The Oceanic Dynamics box is also highly compact and is contained inside a single briefcase. This is designed to create minimal physical impact and to ensure the system can be moved easily between vessels.

Source: UK Electronic Solutions

For more information, go to www.oceanicdynamics.com

Flexible Coupler Kit Eliminates Need for Bonding Jumper

The T&B® Cable Tray flexible coupler kit from Thomas & Betts (T&B) features a bendable plate that allows for electrical continuity, which eliminates the need for a bonding jumper.

The flexible coupler kit also provides maximum horizontal installation flexibility and easy installation that eliminates the need for cutting cable tray side rails.

"We designed the T&B Cable Tray flexible coupler kit to be quickly and easily installed, and it provides excellent cable protection that ensures electrical conductivity without bonding devices," said Ralph Donati, product marketing director at T&B. "It is a flexible and economical alternative to the more common AU/AH fitting."

Other features include an exterior strap that provides an accurate radius for any cable tray design requirements, formed ribs for greater cable protections and no sharp edges. It meets electrical continuity requirements of NEMA VE1 and CSA C22.2 No. 126.1.

Thomas & Betts Corporation, a member of the ABB Group, is a global leader in the design, manufacture, and marketing of essential components used to manage the connection, distribution, transmission, and reliability of electrical power in utility, industrial, commercial, and residential applications.

Source: T&B

For more information, go to www.tnb.com

The flexible coupler kit provides maximum horizontal installation flexibility and easy installation.

High-Power Density CD Couplings Have Smaller Machine Footprint Designs

The quest for smaller machine footprints continues as designers seek new ways to reduce machine size while increasing output. The Zero-Max CD coupling provides precise and reliable shaft connections in less space than other couplings. It operates without fatigue for reliable 24/7 operation required in the latest machine designs. Key to this CD coupling design is the composite flex element. It provides high torsional stiffness, yet allows for misalignment in high-stress applications. In addition, these zero-backlash CD couplings provide smooth operation at high speeds. The coupling's high performance material is configured in a compact design that surpasses the performance of much longer couplings. The space savings enable machine designers to reduce the footprint, saving valuable floor space.

Zero-Max

The Zero-Max CD coupling.

Specific specifications of the CD coupling include:

- 12-inch diameter
- 4.5 inches long
- Continuous Torque Rating: 76,800 inch-pounds
- Torsional Stiffness: 250,000 inch-pounds/degree
- Design Speed: 5,000 rpm
- Engineered specifi ally to operate in sub-critical speed
- Maximum Angular Misalignment: 1.5 inches
- Maximum Radial Misalignment: 0.045 inches
- Maximum axial misalignment: 0.2 inches
- Coupling inertia: 984 pounds/square-inch
- Coupling weight: 43.9 pounds

Designed around Zero-Max's unique composite center disc, Compact CD couplings perform at peak torques in the most hostile operating environments — from extreme cold to hot weather conditions minus-70 degrees to 250 degrees F (minus-57 degrees to 121 degrees C). Applications include drive trains, gearboxes, and generators to provide trouble-free operation in sea water and abrasive desert-sand conditions.

Source: Zero-Max

For more information, go to www.zero-max.com

Senvion Acquires Kenersys Assets in India

Senvion, a leading global manufacturer of wind turbines, will acquire the wind-turbine nacelle production facilities and infrastructure, complete product portfolio suite, wind turbine inventory, and the service operations of Kenersys India Private Limited, in Baramati, India. The production facility of nearly 250 MW of capacity has the potential to be expanded further. Senvion will be able to start its operations with the assets immediately after the closing of the transaction and obtaining the necessary approvals.

The product portfolio of the acquired assets ranges from 2 to 2.6 MW and rotor diameters from 82 to 120 meters, with cumulative installations of 220 MW in India with some of the large local key clients. With this acquisition, Senvion gets full rights to own, enhance, and sell the Kenersys India product portfolio worldwide, including K82 (2.0 MW), K100 (2.6 MW), K110 (2.4 MW), and K120 (2.3 MW) in development. The existing products also are registered with the National Institute of Wind Energy, India, and available for Senvion immediately. Additionally, Senvion takes over the complete Indian service operations of Kenersys India Private Limited (220 MW).

"There are two main advantages of this acquisition: Firstly, we shorten our time-to-market in India rapidly and, secondly, we can build on a strong base to further align the Kenersys products with our existing Indian R&D organization and the well-known technical expertise from our Senvion tech center in Germany," said Senvion CEO Jürgen Geissinger. "By adding 2 MW turbines with rotor diameters of 110 and 120 meters to our existing portfolio, we are able to offer our customers in India even more profitable and cost-efficient Senvion technology. We believe that this acquisition comes at the right time for us when the Indian Government sets its sights on 60 GW of cumulative wind-energy installations by 2022 and will have a positive impact on creating jobs in India for delivering state-of-the-art solutions for India and additional markets."

"Earlier this year, we decided and announced to invest, access, and grow in the Indian market," said Senvion CFO Manav Sharma. "We are a proud member of the Make in India initiative of the Government of India, and this investment strengthens our commitment towards India. With the acquisition of specific Kenersys India assets, we are creating a fusion of Senvion's international growth strategy, high-quality engineering competence, and the Indian market presence of Kenersys. With this transaction, we can combine these assets with Senvion strengths for presenting superior offers to Indian clients. The service business gives us instant access to some of the top independent power producers in India. We will finance the transaction with existing cash on our balance sheet. Our focus now shifts to working with the Kenersys India Team and other stakeholders toward the closing of the transaction."

In February, Senvion announced it was adding India to its core markets and named Amit Kansal as managing director of Senvion India.

"The facilities in Baramati will give Senvion a ready home for production and is further supported by a product portfolio of German-designed products of Senvion and Kenersys India, some of which have already been successfully localized to India, and key client relationships," Kansal said. "We look forward to growing Senvion by a strong mix of bringing top-of-the-line technologies to India, along with significant local knowhow and relationships."

Since 2015, a research and development center in Bangalore is working fulltime to support the Senvion Product Development department, based at the TechCenter in Osterrönfeld in Northern Germany.

Source: Senvion

For more information, go to www.senvion.com

A.K. Suda Liftboat Delivered to Owners

The Suda 320-L4T can work in water depths up to 246 feet.

A.K. Suda has completed the design of a 320-foot (97.5-meter) truss-legged liftboat. This vessel was recently delivered to its owners. The vessel follows on the heels of the 300-foot (91.5-meter) truss leg liftboat delivered earlier this year.

The state-of-the-art vessel is a four-legged, self-propelled, self-elevating, general service liftboat, named Jinshan 1. It is based on the Suda 320-L4T.

It was built by Triyards Marine for Swissco Offshore. It is ABS classed with Unrestricted Service, X A-1, X AMS. The hull dimensions are 182 feet by 114 feet, 10 inches by 14 feet, 9 inches, (55 meters by 35 meters by 4.5 meters). The quarters arrangement can accommodate 146

people including crew. The Suda 320-L4T also has a generous cargo deck area of 950 square meters.

This self-elevating unit can work in water depths up to 246 feet (75 meters). It also has a CAP 437 heliport that can support a Sikorsky S76 or Bell 412 helicopter.

"Our designs have gained worldwide attention due to the fact that they do more for less," said A.K. Suda CEO Ajay Suda. "In some cases, they offer, by far, the lowest cost solution than any other designs in the world. This vessel is no different. It will compare favorably with any vessel of its size in the world. We are confident it will provide the owner a long and profitable service."

Source: A.K. Suda

For more information, go to www.aksuda.com

Vestas Receives 100 MW Order in Michigan

Sempra U.S. Gas & Power has ordered 29 V126-3.45 MW turbines from Vestas. The turbines will be deployed at the 100 MW Apple Blossom wind project in Michigan.

"The turbines at Apple Blossom are another example of the increasing demand for our 3 MW platform in the U.S.," said Chris Brown, president of Vestas' sales and service division in the United States and Canada. "The platform repeatedly proves its versatility across a variety of North American wind regimes and across the Midwestern wind belt, as our customers are benefiting from the five different rotor sizes, taller towers, and different power modes. We're very happy to add this latest agreement to our portfolio with Sempra."

Originally developed by Geronimo, the Apple Blossom wind project was acquired by Sempra in July, while delivery of the turbines is planned for the third quarter of 2017 and commissioning expected in the fourth quarter of that year. Nacelles, blades, and towers will be produced at Vestas' Colorado factories.

Since the Vestas 3 MW-platform's debut, more than 10 GW have been installed globally, both onshore and offshore.

Source: Vestas

For more information, go to www.vestas.com

Siemens to Supply 64 Wind Turbines for U.S. Onshore Project

Siemens has received an order to supply, install, and commission 64 onshore wind turbines for the onshore Grant Plains Wind project in Oklahoma for Apex Clean Energy. The wind-power plant will have a total capacity of 147 MW, and it will generate enough power to supply more than 50,000 households with clean renewable energy. After commissioning later this year, Siemens will additionally be responsible for servicing the wind farm.

The latest order from Apex Clean Energy follows up on the completion of two previous wind-turbine projects in Oklahoma. Within the past year, Siemens commissioned the Grand Wind and Kay Wind project. Including Grant Plains, all three wind-power plants generate nearly 600 MW. That is enough energy to supply about 200,000 average households.

"We are very pleased to receive a follow-up order from Apex Clean Energy to supply turbines for this wind project in Oklahoma," said Jacob Andersen, CEO of Onshore Americas of Siemens Wind Power and Renewables Division. "Once Grant Plains is operational, our expert service technicians from


Siemens

throughout the Midwest — including Oklahoma — will ensure the turbines perform at maximum capacity for many years to come."

The Grant Plains Wind project will feature Siemens' SWT-2.3-108 wind turbine with a rotor diameter of 108 meters and a hub height of 80 meters. The units are part of the company's Onshore Geared platform — the workhorse of Siemens' installed portfolio with rotor diameters optimized for all wind conditions. The Onshore Geared platform features highly engineered, designed, and manufactured components with exceptional reliability and low operational costs.

The nacelles and hubs for the Grant Plains Wind project will be assembled at the Siemens facility in Hutchinson, Kansas. The blades will be manufactured at the Siemens blade facility in Fort Madison, Iowa. Siemens has a 64,000-square-foot wind service distribution center in Woodward, Oklahoma.

Nearly 6,000 Siemens wind turbines are installed in the United States. Combined, they produce enough clean and renewable energy to provide more than 4.2 million households with electricity daily.

Source: Siemens

For more information,
go to www.siemens.com/wind

The Grant Plains Wind project will use SWT-2.3-108 turbines like the Broadview project (above).

Experiencing Turbulence

University of Delaware study predicts U.S. offshore wind might be more powerful and abundant than originally thought.

By Kenneth Carter

The Anholt Wind Farm in Denmark is an example of an irregular layout, according to UD professor Cristina Archer.

Some surprising findings about how the wind behaves at the Cape Wind tower near Nantucket Sound might end up being good tidings for offshore wind in the U.S.

A recent study published in the *Journal of Geophysical Research: Atmospheres* shows the wind in that area is unstable more than 60 percent of the time.

On the surface, "unstable" would seem to be have a negative connotation, but not so when it comes to wind power.

Researchers analyzed more than 10 years of data collected at the Cape Wind tower including data gathered from newly installed instruments as well as information recorded by airplane flyovers, said lead researcher Cristina Archer.

That dataset was used to determine the nature of the wind surrounding the tower. Was it unstable, stable, or neutral?

UNDERSTANDING ATMOSPHERE

Which one of those designations the wind falls into has to do with the thermal stratification of the atmosphere and the atmosphere in general, according to Archer, an associate professor at the University of Delaware in the College of Earth, Ocean, and Environment's School of Marine Science and Policy and Department of Geography and a governing member of the Center for Carbon-free Power Integration.

Archer explains that the forces behind the atmosphere's behavior are a little complicated, but understanding how the atmosphere behaves is key to understanding how wind behaves.

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AD INDEX

In an unstable or turbulent atmosphere, the air is vigorously mixed with eddies, Archer said. The heat comes up from the surface, which causes warmer air to rise and cooler air to go down where it gets mixed. In an unstable atmosphere, the turbulent mixing also brings down the stronger winds from aloft, resulting in relatively uniform distribution of high winds around the hub height of wind turbines, which is typically greater than 100 meters offshore.

"Unstable conditions are generally beneficial for wind energy production because all that high wind that usually is above is mixed down," Archer said. "So you get high winds closer to the surface of the water and around the turbine rotor. There is vigorous mixing; there are eddies, and there is turbulence when the atmosphere is unstable."

That turbulence does have a downside, because it can cause undue stress on the turbine blades.

UNSTABLE ADVANTAGE

"But it also has a hidden benefit," Archer said. "You have a farm, so now you have more than one turbine. So there is a turbine in front, and there is a turbine behind it. The turbine behind has less wind than the one up front because the turbine up front takes away some of the wind. But if you put the second turbine farther and farther away from the first, then eventually it's unaffected by the presence of the first turbine."

That gap between turbines is called the wake.

"If the atmosphere is unstable, this wake is short, and if the atmosphere is stable, then this wake can be very long," Archer said. "There's a long 'tail' behind the front row."

Another advantage of what Archer and her team found at Cape Wind is that, since the wind is unstable, turbines in a wind farm would have shorter wakes.

"You can place these turbines closer to each other, which is a benefit because when you have a lease for building a farm, maybe originally you were planning to put 10 turbines in it because you had to have enough space for the wake to dissipate," she said. "But now you can put, say, 12 in because the wakes are actually on average shorter than previously thought."

This unstable atmosphere has three effects, according to Archer.

It brings in more wind, the turbulence could have an adverse effect on blades, and shorter wakes mean more turbines in a wind farm.

"So the story is more positive than negative, because we have more wind and shorter wakes," Archer said. "So we can actually generate more power."

The findings — whatever the possible benefits for U.S. offshore wind — were surprising, she said.

The researchers expected the wind at Nantucket Sound to behave much like it does in Europe.

"But it didn't," Archer said.

The atmosphere at European sites is neutral about 60 percent of the time, according to Archer. But at Nantucket, it is unstable 61 percent of the time.

"Stable and unstable are kind of like the extreme cases, and neutral is the common assumption," she said. "And we found at Cape Wind, it's actually unstable most of the time, which is surprising."

It's too soon to tell whether this phenomenon is unique to Cape Wind or if it is indicative of other parts of the U.S. coast leased for offshore wind. But Archer said her team plans to look at data from the Block Island Wind Farm — America's first offshore facility — to see if it mimics the Cape Wind findings.

If it does prove to be a common occurrence, the unstable wind factor certainly will affect how future wind farms are planned, according to Archer.

"Turbine manufacturers want to know how turbulent your environment is because there might be some design in support of the blades for high turbulence versus low turbulence," she said. "So that's another factor that could be important to know in the U.S. now that we have offshore wind finally."

WIND-FARM DESIGN

Predominant unstable wind also will determine how wind farms are designed.

"Right now, we're optimizing with neutral conditions under the assumption that it was working for Europe, and that's how we designed the farms," Archer said. "Design for unstable conditions (means) you can add more turbines, and the distances between the turbines can be shorter, and so the farm might look different."

The layout of a wind farm is crucial to making sure it captures the optimal amount of wind.

"We've already found that you almost never want to have a regular layout," Archer said. "If you have a regular, grid-like layout, there will be some directions in which a lot of turbines are interfering with each other. If you have an irregular layout, then the chance that the wind will be aligned with more than a few turbines is none, so you will only have a few turbines that are in alignment with each other."

In order to achieve that, the fewer turbines interfering with each other, the better.

"And knowing whether (the atmosphere) is unstable or neutral or stable is actually very important because you will have different spacing," Archer said.

The research team for the paper, titled "On the Predominance of Unstable Atmospheric Conditions in the Marine Boundary Layer Offshore of the U.S. Northeastern Coast," includes University of Delaware professors Dana Veron and Fabrice Veron, and Stony Brook University professor Brian Colle and his student Matthew Sienkiewicz.