

Giving Wind Direction

WIND SYSTEMS

IN FOCUS

Systems & Parts

PROTECTING TURBINES FROM HIGH-FREQUENCY VOLTAGE

CONVERSATION

Scott Bryan ► World Wind & Solar

MARCH 2021
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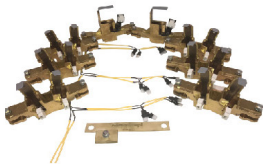
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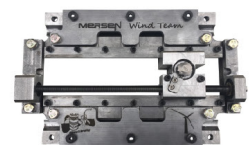
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IN FOCUS

PROTECTING TURBINES FROM HIGH-FREQUENCY VOLTAGE

High-frequency voltage can be destructive to a turbine's bearings, but technology exists to properly ground it before it can inflict any damage.

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FROM THE EDITOR

Focusing on parts, systems of a turbine

I feel like it's at least a little comforting to know that, even though we're still living through a pandemic that has caused so much disruption to our lives, the industry is pushing green initiatives that are making wind grow bigger and stronger in order to create a better and brighter future for everybody.

Case in point, 2020 was a record year for wind — especially during the final quarter of the year, according to the American Clean Power Association. For more details, check out the highlights from that report on the next page.

When the parts come together to create the whole, it's a testament to what wind can accomplish, and I see that boom continuing into 2021 and beyond.

This issue of *Wind Systems* also looks to the parts that make up the whole as we take a deep dive into systems and components that come together to make a wind turbine generate power as efficiently as possible.

Starting with our inFocus section, I talked with Jens Leipner of EST, where we discussed the best methods to properly ground high-frequency voltage that can build up in a turbine generator and cause damage.

You'll also find an interesting article that looks at how magnets can be used in turbines to lower costs, improve reliability, and increase maintenance intervals.

And when it comes to turbine control systems, it's important to know the fundamental concepts that keep turbines spinning. In an article from NI, experts share their insight on how turbine control is essential for optimal performance, safe operation, and structural stability.

In addition to our main articles, we present a fascinating Conversation with World Wind & Solar's Scott Bryan. As vice president of that company's wind division, Bryan discusses WWS' newest services and how they will be beneficial to an ever-growing industry.

Wind is accomplishing big things, and *Wind Systems* is excited to be along for the ride. I hope you enjoy this month's issue as much as I did cobbling it together. And if you have any suggestions on how to improve what we bring to you, don't hesitate to shoot me a message. I'd love to hear from you.

I hope you're looking forward to spring as much as I am, and, as always, thanks for reading!



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Published by Media Solutions, Inc.
P.O. Box 1987 • Pelham, AL 35124
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Industry closes record 2020 with strong Q4

From American Clean Power

The U.S. wind industry had its strongest year ever in 2020 as the amount of new wind power capacity added increased by 85 percent over 2019. The industry added 16,913 MW of wind power capacity to the grid in 2020 – enough to power more than 5 million American homes. Most of this growth came in the fourth quarter, when developers commissioned 10,593 MW of capacity, smashing all quarterly records. With these additions, there are now 122,478 MW of operating wind power capacity in the United States, providing enough power for 38 million American homes.

Project owners commissioned 54 new wind projects across 20 states in the fourth quarter, including two of the nation's largest single-phase wind projects in history in New Mexico and Texas. On the heels of this activity, another 34,757 MW of wind projects are either under construction or in advanced development. Direct utility ownership of wind power continued to grow, while corporate power purchase agreements (PPAs) lagged due to uncertainty caused by COVID-19.

These findings and the latest industry data are highlighted in the newly released ACP Market Report Fourth Quarter 2020 by the American Clean Power Association (ACP).

"2020 was a banner year for the wind industry," said ACP CEO Heather Zichal. "Despite all the challenges COVID-19 placed on our businesses, we still shattered nearly every record for capacity and growth. The fourth quarter was not only the strongest quarter on record, but it also saw more wind installed in just that quarter than in any full year in the modern industry's 40-plus year history, except 2012."

The record-breaking growth was due to a number of factors, including strong continued demand from American consumers for clean energy to power their homes, as well as technological improvements that have allowed renewable energy prices to become more and more competitive in the marketplace.



American Clean Power is the voice of companies from across the clean-power sector that are powering America's future. For more information, go to www.cleanpower.org




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DIRECTION

THE FUTURE OF WIND

Tatanka Ridge encompasses approximately 18,000 acres of primarily corn and soybean farms and cattle ranches. (Courtesy: Acciona)



Tatanka Ridge Wind Farm achieves commercial operation

Avangrid Renewables recently completed commissioning of the 154.8 MW Tatanka Ridge Wind Farm January 5, 2021. The facility's 56 wind turbines are in Deuel County, South Dakota, northeast of Brookings.

The facility is owned by Tatanka Ridge Wind, LLC, which is jointly owned by Avangrid Renewables and WEC Energy Group.

Dairyland Power Cooperative has a power purchase agreement with Tatanka Ridge Wind, LLC for 51.6 MW of renewable energy. Dairyland's portion of Tatanka Ridge's output will deliver enough renewable energy to power approximately 16,000 homes. The balance of the project's generation is contracted to a large commercial customer.

"Dairyland is pleased to work with Avangrid Renewables and WEC Energy Group on an efficient and sustainable facility that supports our transition to a lower carbon future," said Brent Ridge, Dairyland President and CEO. "Diversification of resources is a key element of Dairyland's Sustainable Generation Plan, making Tatanka Ridge a valuable addition to our cooperative's renewable energy portfolio."

Dairyland and Avangrid Renewables have collaborated twice before on wind-energy facilities, Barton Wind (Kensett, Iowa) and Winnebago Wind (Thompson, Iowa).

"Avangrid Renewables has been pleased to work with Dairyland Power to make Tatanka Ridge a reality," said Alejandro de Hoz, president and CEO of Avangrid Renewables. "Partners such as Dairyland have helped to build the wind industry in the Midwest and drive the transition to a clean energy future."

Tatanka Ridge encompasses approximately 18,000 acres of primarily corn and soybean farms and cattle ranches, leased from more than 100 landowners. Between land lease payments and taxes, the wind farm will provide \$1.7 million in local econom-

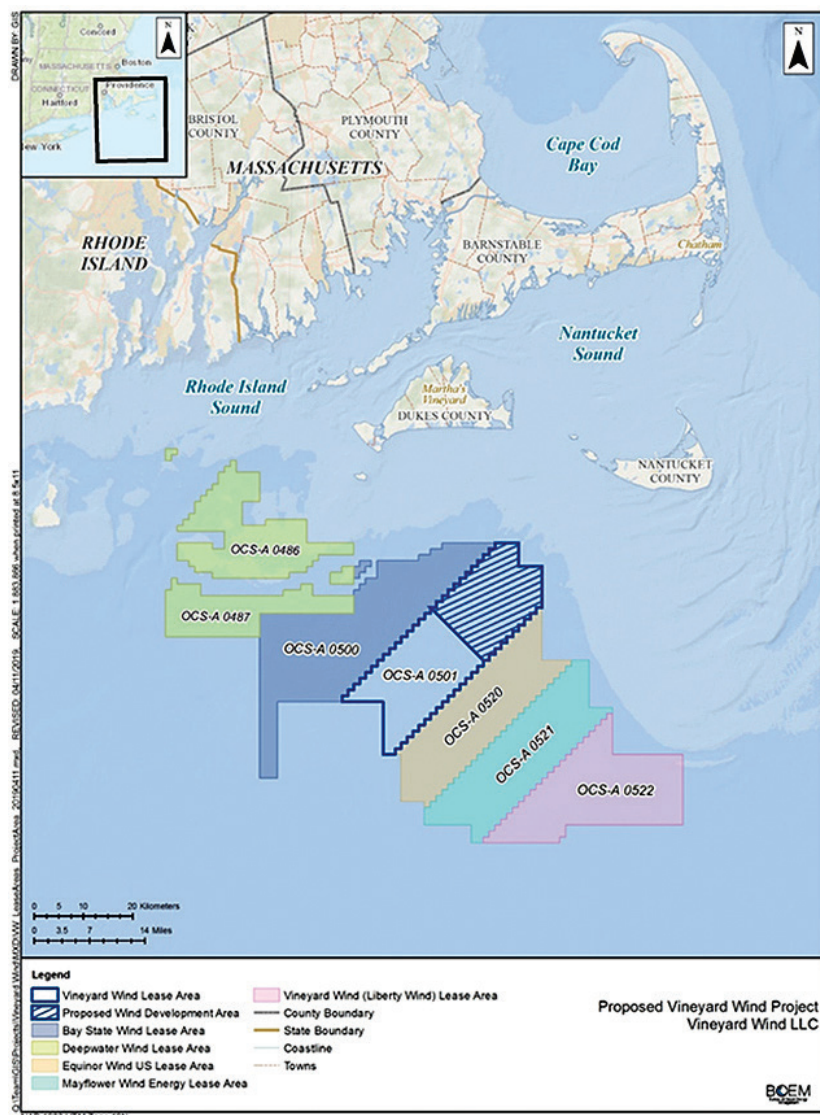
ic benefits annually over the life of the project.

In July 2020, Avangrid Renewables announced the sale of an 85 percent ownership interest in Tatanka Ridge Wind, LLC, to WEC Energy Group of Milwaukee. This transaction closed in December 2020.

MORE INFO avangridrenewables.com

BOEM to resume review of Vineyard Wind project

In support of the Biden administration's goal to address climate change and promote offshore renewable energy production, the Bureau of Ocean Energy Management (BOEM) recently



The Vineyard Wind project would be about 12 nautical miles offshore Martha's Vineyard and 12 nautical miles offshore Nantucket in the northern portion of its lease area. (Courtesy: BOEM)



Around the world, 14 Vaisala facilities are powered by renewables. (Courtesy: Vaisala)

announced it intends to resume the environmental review of Vineyard Wind's proposed offshore wind project.

"Offshore wind has the potential to help our nation combat climate change, improve resilience through reliable power, and spur economic development to create good-paying jobs," said BOEM Director Amanda Lefton. "BOEM is committed to conducting a robust and timely review of the proposed project."

BOEM will resume the environmental review of the Vineyard Wind Project and proceed with development of a Final Environmental Impact Statement.

On January 22, 2021, Vineyard Wind submitted a letter rescinding its temporary Construction and Operations Plan (COP) withdrawal and requesting that BOEM resume review

of the 800-MW wind-energy project offshore Massachusetts. The proposed project would be about 12 nautical miles offshore Martha's Vineyard and 12 nautical miles offshore Nantucket in the northern portion of its lease area. Vineyard Wind had paused the Department's consideration of its proposal while it reviewed whether the use of Haliade-X turbines warranted any modifications to their COP.

President Joe Biden issued an executive order on January 27, 2021, that called for the Interior Department to identify steps to accelerate responsible development of renewable energy on public lands and waters. Interior has initiated a review of processes and procedures to date as it re-invests in a rigorous renewable energy program.

MORE INFO www.boem.gov/vineyard-wind

Vaisala achieves its target to use 100% renewable electricity

As a member of the RE100 initiative, Vaisala, a global leader in weather, environmental, and industrial measurements, has achieved its target to use 100 percent renewable electricity by the end of 2020.

The goal covered all Vaisala's facilities with significant energy consumption around the globe and was reached with the combination of self-produced clean energy in Finland and the United States as well as green electricity from local energy companies. Among Finnish companies, Vaisala is the first technology company and second overall to achieve the RE100 target. In to-

tal, 17 companies in the Nordics have committed to RE100.

Sustainable solutions and business practices have always been at the core of Vaisala. In 2015, Vaisala joined RE100, the Climate Group's global initiative encouraging the world's most influential companies to make a 100 percent renewable electricity commitment within a clear timeframe. Vaisala set the target to use 100 percent renewable electricity in its facilities by the end of 2020.

"As the environmental and economic impacts of climate change increase, we need to implement different mitigation practices," said Kai Öistämö, president and CEO of Vaisala. "We see that the private sector needs to be a key driver of change and accelerate the transition to a low-carbon economy. Therefore, I am proud to say Vaisala has achieved the important goal of using 100 percent renewable electricity."

"By rapidly switching to 100 percent renewable power, Vaisala is leading by example and showing it makes business sense — even in these challenging times," said Mike Peirce, Corporate Partnerships Director at the Climate Group. "Vaisala's success will inspire others to strive for the same goal and walk the talk on sustainable technologies — if we're to halve emissions this decade, there's no time to lose."

Following the initiative, Vaisala took several actions to ensure 100 percent renewable electricity in its facilities with significant energy consumption. In total, 14 Vaisala facilities around the world are powered by renewables. The target was achieved with a combination of self-produced energy and green electricity products purchased from local energy companies.

About 94 percent of the electricity that Vaisala's facilities consume comes directly from renewable sources, mainly from wind power. This 94 percent comprises Vaisala's largest facilities, where it is possible to affect consumption with self-produced energy and local green energy. For instance, Vaisala's manufacturing sites in Finland and the United States use

solar panels to produce clean energy.

The remaining 6 percent consists mostly of small office facilities where Vaisala is not the sole proprietor of the building and therefore cannot directly choose to consume renewable electricity. This remaining part was covered by purchasing unbundled renewable energy attribute certificates from the market. An energy-attribute certificate is a market-based instrument that proves that 1 MWh of renewable energy has been produced in the same region. With these certificates, Vaisala was able to cover electricity consumption on those sites that cannot negotiate their own electricity contracts.

Throughout its 85-year history, Vaisala has created innovations that help to build a better future by mitigating environmental impacts but also adapting to them. Vaisala's solutions for weather and environment as well as for industrial sectors help customers to make smart decisions concerning weather events and the use of energy and other resources. For instance, wind-energy operators and biogas producers can get reliable measurement data on their operations and thus produce sustainable energy efficiently. In this way, Vaisala helps to increase the amount of and access to clean energy globally.

"The positive handprint of our business is formed through our multitude of measurement solutions," Öistämö said. "We are strongly involved in the renewable energy industry through our customers, but it is also essential that we advance the use of renewable energy sources in our own operations."

MORE INFO vaisala.com

Energy heavyweights to rejuvenate older European wind parks

Combining more than 100 years' experience in energy, green finance, and M&A across its senior team, NeXtWind recently launched its strategy to become Europe's next major green inde-

pendent power producer (IPP).

Backed by established sustainable investors including Crestline Investors, Ferd, and ARB Investment Partners, the company will initially seek to acquire and rejuvenate older, most likely teenage, wind parks in Germany.

Working with local communities and partners to bring new life, higher performance, and shared benefit to existing sites, NeXtWind's strategic goal is to acquire and transform a portfolio in excess of 1GW of end-of-regulatory-life European assets.

"The older wind sites tend to have the best locations but the worst efficiencies," said Ewald Woste, NeXtWind CEO. "We've assembled the expertise and funding to ensure that these sites are not lost to a diminishing baseline of clean power. Indeed, with smart investment and management, we expect to double the average wind harvest from these pioneering parks. With Germany phasing out coal and nuclear generation, this is important work."

"The energy transition must keep moving forward and an increasingly important ingredient to that will be the rejuvenation of Europe's early green energy parks," said Lars Meyer, Chief Investment Officer at NeXtWind. "In Germany alone, we estimate that some 15 GW of teenage onshore wind capacity will soon need to navigate today's market complexities and determine a proactive plan for a future that looks very different to the present. It's an extremely fragmented market in need of consolidation, modernization, and significant investment."

With an active M&A pipeline already in place, NeXtWind was expected to complete the acquisition of its first sites soon. Acquired sites will either be repowered or undergo lifetime extension works. The company is negotiating framework agreements with some of Europe's largest utilities in order to facilitate the signature of future Power Purchase Agreements (PPAs). ↘

MORE INFO www.nextwind.de

IN FOCUS

SYSTEMS & PARTS

PROTECTING TURBINES FROM HIGH- FREQUENCY VOLTAGE





The AEGIS® PRO Ring encloses the shaft with hundreds of thousands of conductive microfibers. Because these fibers cover a large surface area, they have a low impedance for high-frequency currents. (Courtesy: EST)

High-frequency voltage can be destructive to a turbine's bearings, but technology exists to properly ground it before it can inflict any damage.

By KENNETH CARTER ▀ Wind Systems editor

The generator within a wind turbine is capable of producing up to 5 GW of electricity. An unfortunate side effect of that is that voltage can build up within the generator itself.

That voltage naturally runs to ground, but along that path, the voltage arcs through the bearings within the generator's rotor.

This constant discharge of high-frequency voltage through the rotor bearings causes microscopic damage that can eventually lead to generator failure, a costly problem to say the least.

"The voltage exists because you drive the generator with a frequency converter, or variable frequency drive," said Jens Leipner, Electro Static Technology's Sales Manager, Northern Europe. "That means you couple the voltage inside the rotor. The rotor is inside the generator and is held by two bearings — on the drive inside and on the non-drive inside. This voltage wants to go to the ground, and the only possible path to go to the ground is through the bearings. And if you have high voltage on the rotor, and that wants to transfer to the bearings, then it will have to pass through the balls inside the bearings. And there's a little grease film inside the bearings, too, just as an insulating part. The voltage grows more and more and sparks through the grease film."

MICROPITTING

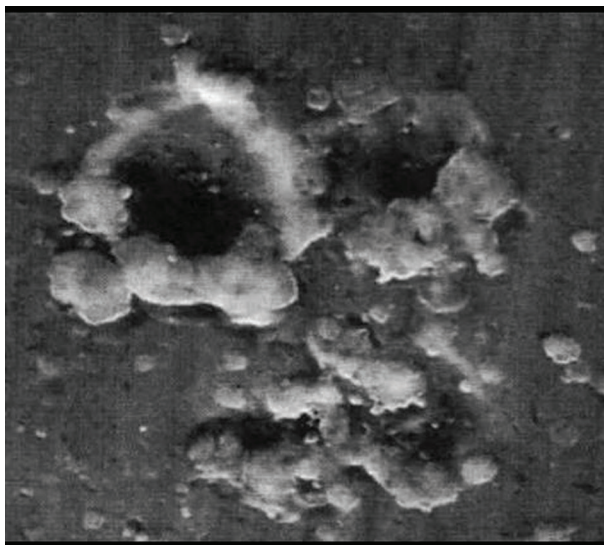
As the voltage arcs through the bearings, microscopic pits begin to form. These pits are the result of high-frequency current running through the oil or grease film, causing a little spark inside, according to Leipner.

"Every spark produces this little pit," he said. "And the result of this is a washboard pattern surface on the bearing. And the balls in the bearings get very loud and get hot, and then the bearing breaks."

This voltage can create almost 16,000 pits per second, resulting in a frosted, washboard pattern. As the washboarding becomes more prominent, the bearings begin to make noise, and eventually, they will break, forcing the generator within the turbine to shut down.

"You can imagine the problems that arise in order to pick up this big generator with a big crane, and then it's so much money to put it on the ground and repair it," Leipner said.

Sometimes the bearings at the top of a turbine can be changed, but that can also prove difficult since the bearings



Localized corrosion (pitting) in a bearing shell (magnified) as a result of spark erosion when shaft voltage is discharged through the bearings, leaving behind small melt craters. (Courtesy: EST)



Gear with tiger striping. (Courtesy: EST)



Bearing with fluting formation. (Courtesy: EST)

are about 300 to 400 millimeters in diameter.

CARBON BLOCK BRUSHES

In the past, carbon block brushes have been used in grounding systems, but carbon block brushes are insufficient in that they are mainly effective against low-frequency voltage, and they produce a layer on the shaft that looks like a gray patina, which is why the brushes don't work well for grounding high-frequency voltage.

"It's a very, very interesting thing," Leipner said. "I have measured a very big generator with 8 MW where they have installed carbon block brushes on the shaft. They had problems with the gearbox behind this, so they asked us if we could measure this. We measured 40 volts peak-to-peak with the touching carbon block brush on the shaft. So, you can see that the carbon block brush does not work for high-frequency voltage. It was a really interesting measurement."

Most wind turbines today use doubly inverter-fed induction generators, according to Leipner.

"That means you have a slip ring on the one side to three phases to produce the electrical magnetic field inside the rotor," he said. "They have three phase rings and one grounding ring. There are also those carbon block brushes running on it. And this is normally for grounding, but remember, the carbon block brushes don't ground the high-frequency voltage."

GROUNDING HIGH-FREQUENCY VOLTAGE

With technology in place to sufficiently ground the low-frequency voltage, it became necessary to tackle a way to properly ground the high-frequency voltage that could eventually force a major turbine shutdown.

To prevent this from causing potential turbine failures, Electro Static Technology developed the AEGIS® PRO Ring.

These grounding rings enclose the shaft with hundreds of thousands of conductive microfibers. Because these fibers cover a large surface area, they have a low impedance for high-frequency currents.

The development of the AEGIS® PRO Ring came from work done with printers, where fibers would brush up against a piece of paper to remove the electrostatic charge, according to Leipner.

"This was the development of our ring," he said. "So, we made a round one that was much more fibrous with special fiber to touch the shaft. That was the beginning of AEGIS® in 2005. Now it's been on the market nearly 15 years."

The AEGIS® ring creates a shortcut next to the bearing for the high-frequency voltage to move through.

"The high-frequency voltage on the shaft wants to go through the bearing, but we make a shortcut with our AEGIS® ring," Leipner said. "Now the high-frequency voltage passes through the AEGIS® ring from the shaft to the fiber



Wind power expert Jens Leipner at the generator level of the wind turbine on which the measurements were performed. (Courtesy: EST)

and then to the ring and to the ground from the motor.”

For wind turbines, in order to prevent both the low- and high-frequency voltage from damaging the turbine’s parts, a combination of the carbon block brush with the slip ring, along with the AEGIS® ring, is often used, according to Leipner.

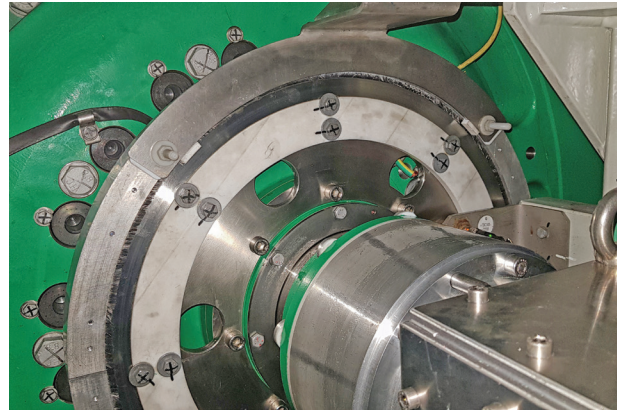
The high-frequency voltage can be measured on a running turbine, and Leipner said tests were performed to determine what kind of an effect the high-frequency voltage could have on a running system.

MAKING A CASE FOR AEGIS®

Electro Static Technology performed measurements on a turbine for a generator manufacturer on a 140-meter high turbine with a 135-meter blade diameter with a permanently excited generator with VFD control.

The generator was already equipped with brake disc rollers for low-frequency grounding. It also had shaft grounding in the form of a “violin bow” for high-frequency voltage.

Without any shaft grounding, the high-frequency shaft voltage was a dangerous 20 volts peak-to-peak. With the “violin bow,” the voltage could be reduced to slightly more than 4 volts. Below 5 volts is a safe level for the shaft voltage, but the “violin bow” was experiencing heavy wear because these components are pressed under tension against a spinning shaft. As a result, they can wear through quickly.



After installing the AEGIS® PRO ring during a test, the shaft voltage was reduced to less than 1 volt. (Courtesy: EST)

OUTLASTING THE LIFE OF THE BEARINGS

After AEGIS® PRO rings were installed, the residual shaft voltage was reduced to less than 1 volt. Furthermore, since the fibers of the ring are not under tension, they become much more durable than other grounding systems.

“The very good thing is that we have nearly no wear rate on the AEGIS® fiber,” Leipner said. “That means about 0.03 millimeters of wear in 10,000 hours, which translates into 10 to 20 years of running it with no problems.”

With the life of a bearing clocking in at about 10 years, that means an AEGIS® PRO ring can theoretically outlast the bearing that it’s protecting.

“The fibers touching the shaft are very smooth and very soft, so we don’t destroy the shaft or the surface from the slip ring; everything runs freely,” Leipner said. “We say a bearing lifetime normally is 8 or 10 years, but with the AEGIS® PRO ring, if everything is perfect, you can actually use it again.”

OTHER INDUSTRIES

With the AEGIS® Shaft Grounding Ring’s ability to ground high-frequency voltage, the technology has made its way into many different industries.

“That means motors where you normally have problems with the frequency converter,” Leipner said. “Every motor with a frequency converter has high-frequency shaft voltage that wants to go to the ground. This happens in applications from water treatment to manufacturing to HVAC/R. So, we normally produce these rings for those industries, but also for electric vehicles, ranging from cars to trains.”

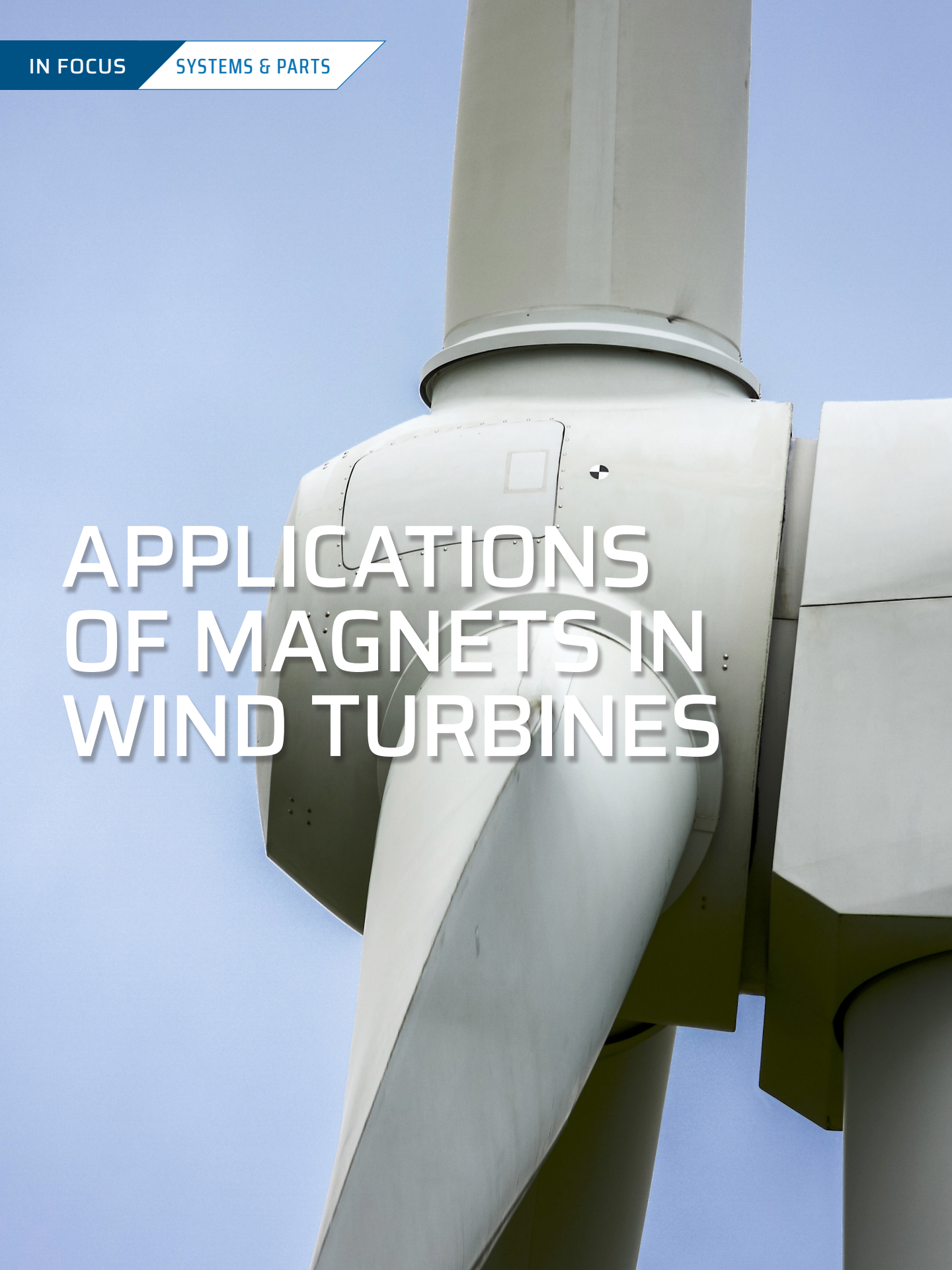
The need to ground high-frequency voltage is evident in the success the AEGIS® Shaft Grounding Ring has had within the wind-energy market, according to Leipner.

“The main results of the ring are that they have no wear rate, that you have no maintenance after you install the ring,” he said. “And also, you can see that it’s working. You can see it from the field.”

MORE INFO

www.est-aegis.com

APPLICATIONS OF MAGNETS IN WIND TURBINES

A low-angle, close-up photograph of a wind turbine's nacelle and blades. The turbine is white, and the background is a clear blue sky. The perspective is looking up at the tower and nacelle, with one blade extending towards the bottom left and another towards the right. The text 'APPLICATIONS OF MAGNETS IN WIND TURBINES' is overlaid in large, white, sans-serif capital letters.

Magnets are being used to lower costs, improve reliability, and increase maintenance intervals in many wind farms around the world.

By DAVID PIPER and JUDITH M. GUIDO

Permanent magnets play a critical role in some of the world's largest wind turbines. Rare earth magnets, such as powerful neodymium-iron-boron magnets, have been used in some wind-turbine designs to lower costs, improve reliability, and reduce the need for expensive and ongoing maintenance.

WIND TURBINE GENERATORS

In 1831, Michael Faraday created the first electromagnetic generator. He discovered that an electric current can be created in a conductor when it is moved through a magnetic field. Nearly 200 years later, magnets and magnetic fields continue to play an integral role in modern electric power generation. Engineers continue to build upon Faraday's inventions, with new designs to solve 21st century problems.

Some utility scale wind-turbine designs use induction generators to produce electricity. Induction generators use electromagnets designed into a rotor assembly to create a magnetic field. These electromagnets take a small amount of current from the power system to generate a magnetic field in the rotor, which is then rotated within the generator near stationary coils of wire. This rotating magnetic field induces a large current in the stationary coils of wire, which can then be used to power homes, schools, and businesses.

This design typically requires slip rings to power the electromagnets and a gearbox to convert the low rotational speed of a turbine shaft to the higher speeds that induction generators require in order to produce electricity. These gearboxes can be massive, typically weighing between 15 and 80 tons. The added weight of a gearbox requires designers to build stronger (and more expensive) towers. Gearboxes also require ongoing periodic maintenance, which can be challenging in certain applications, such as offshore windfarms. In addition, gearboxes cause friction losses and reduce overall efficiency.

A permanent magnet synchronous generator is an alternate type of wind-turbine generator. Unlike induction generators, these generators use the magnetic field of strong rare-earth magnets instead of electromagnets. They do not require slip rings or an external power source to create a magnetic field. They can be operated at lower speeds, which allows them to be powered by the turbine shaft directly and, therefore, do not require a gearbox. This reduces the weight of the wind-turbine nacelle and means towers can be produced at a lower cost. The elimination of the gearbox results in improved reliability, lowered maintenance costs, and improved efficiency. The ability of magnets to allow designers to remove mechanical gearboxes from wind turbines is illustrative of how magnets can be used innovatively in solving both operational and economic problems in modern wind turbines.

MAGNETIC MOUNTING SOLUTIONS FOR LADDERS AND OTHER EQUIPMENT

The interior of a wind turbine is filled with cables, ladders, and sometimes elevators to allow workers to access the turbine nacelle. This equipment must be secured to the wall of the tower. The traditional solution to this problem was to either drill holes for mounting brackets through the tower wall or to weld brackets directly to the tower. However, drilling holes through the tower wall reduces its mechanical strength and creates opportunities for metal fatigue and corrosion, which can sacrifice the integrity and safety of the tower. Welding brackets directly to the tower requires skilled labor. Both solutions increase overall construction time and cost.

Some wind-turbine manufacturers have developed magnetic mounting systems that securely attach ladders and other equipment to the steel tower walls. This method allows equipment to be secured to the tower without the need to drill holes or weld brackets to the tower walls. This progressive mounting solution reduces construction time and costs without causing opportunities for either metal fatigue or corrosion and is yet another illustration of how magnets can be used effectively in solving operational and financial constraints in modern wind turbines. The use of several strong neodymium magnets strategically placed along the entire length of the ladder increases worker safety by securing the ladder in a manner that prevents swaying or other lateral movement that could cause a worker to slip and fall, causing physical harm to individuals as well as operational and financial harm to the company and industry at large.

SUSTAINABILITY AND GROWTH OF WIND ENERGY AS A RENEWABLE RESOURCE

Wind energy is among the fastest growing sources of energy in the utility sector today. U.S. wind producers are expected to double the existing production capacity from 113 GW in 2020 to 224 GW by 2030. [1]

"The enormous benefits of utilizing magnets in wind turbines to produce a cleaner, safer, more efficient and economically viable source of wind energy has enormous positive implications for our planet, population and the way we live and work," said Adam Poling, Amazing Magnets Chief Operating Officer.

As such, the company is committed to dedicating multiple resources to this renewable resource and space.

Wind is a clean and renewable fuel source that can be used in the production of electric power. Wind turbines can be used in conjunction with other renewable energy sources to help states and countries meet renewable portfolio standards and emissions targets to slow the rate of climate change. Wind turbines do not emit carbon dioxide or oth-



Some wind-turbine manufacturers have developed magnetic mounting systems that securely attach ladders and other equipment to the steel tower walls. (Courtesy: Amazing Magnets)

er harmful greenhouse gases, which makes wind-powered energy better for the environment than fossil fuel-based sources.

In addition to reducing greenhouse gas emissions, wind energy provides additional benefits over traditional power generation sources. Nuclear, coal, and natural gas power plants use a surprisingly large amount of water in the production of electric power. In these types of power plants, water is used to create steam, control emissions, or for cooling purposes. Much of this water is ultimately released into the atmosphere in the form of condensation. Conversely, wind turbines do not require water to produce electricity.

Wind farms' value therefore increases exponentially in arid regions where the availability of water is limited.

Perhaps an obvious but significant benefit of wind power is the fuel source is essentially free and sourced locally. In contrast, fuel costs of fossil fuels can be one of the largest operating costs for a power plant and may need to be sourced from foreign suppliers that can create a dependence on interruptible supply chains and can be affected by geopolitical conflicts. This means wind energy can help countries become more energy independent and reduce the risk of price fluctuations in fossil fuels.

Unlike finite fuel sources such as coal or natural gas,



wind is a sustainable energy source that does not require fossil fuels to generate power. Wind is produced by temperature and pressure differences in the atmosphere and is a result of the sun's heating the Earth's surface. As a fuel source, wind provides an infinite supply of energy and, as long as the sun continues to shine, wind will continue to blow.

CONCLUSION

Magnets play an important role in some of the world's largest wind turbines. Wind is one of the fastest growing sources of clean energy. As such, the role magnets play in helping create this clean energy should not be overlooked, as it is aligned with the mega-trend of sustainability and

all of its benefits. Magnets are being used to lower costs, improve reliability, and increase maintenance intervals in many wind farms around the world and are also being used to reduce construction costs of new turbines by eliminating the need for more costly equipment mounting designs. ✌

REFERENCES

[1] www.energy.gov/eere/wind/wind-vision

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IN FOCUS

SYSTEMS & PARTS

WIND TURBINE CONTROL METHODS



Exploring the fundamental concepts and control methods/techniques for wind-turbine control systems.

By NI

Wind-turbine control is necessary to ensure low maintenance costs and efficient performance. The control system also guarantees safe operation, optimizes power output, and ensures long structural life. Turbine rotational speed and the generator speed are two key areas that you must control for power limitation and optimization. The “Control Methods” and “Control Strategies” sections of this article explain which techniques to use and how to manage these areas.

WIND TURBINE OPERATION

A wind turbine is a revolving machine that converts the kinetic energy from the wind into mechanical energy. This mechanical energy is then converted into electricity that is sent to a power grid. The turbine components responsible for these energy conversions are the rotor and the generator.

The rotor is the area of the turbine that consists of both the turbine hub and blades. As wind strikes the turbine’s blades, the hub rotates due to aerodynamic forces. This rotation is then sent through the transmission system to decrease the revolutions per minute. The transmission system consists of the main bearing, high-speed shaft, gearbox, and low-speed shaft. The ratio of the gearbox determines the rotation division and the rotation speed that the generator sees. For example, if the ratio of the gearbox is N to 1, then

the generator sees the rotor speed divided by N . This rotation is finally sent to the generator for mechanical-to-electrical conversion.

Figure 1 shows the major components of a wind turbine: gearbox, generator, hub, rotor, low-speed shaft, high-speed shaft, and the main bearing. The purpose of the hub is to connect the blades’ servos that adjust the blade direction to the low-speed shaft. The rotor is the area of the turbine that consists of both the hub and blades. The components are all housed together in a structure called the nacelle.

ANGLE OF ATTACK

The amount of surface area available for the incoming wind is key to increasing aerodynamic forces on the rotor blades. The angle at which the blade is adjusted is referred to as the angle of attack, α . This angle is measured with respect to the incoming wind direction and the chord line of the blade. There is also a critical angle of attack, $\alpha_{critical}$, where air no longer streams smoothly over the blade’s upper surface. Figure 2 shows the critical angle of attack with respect to the blade.

POWER AND EFFICIENCY

This section explains what affects the power extracted from the wind and the efficiency of this process. Consider Figure

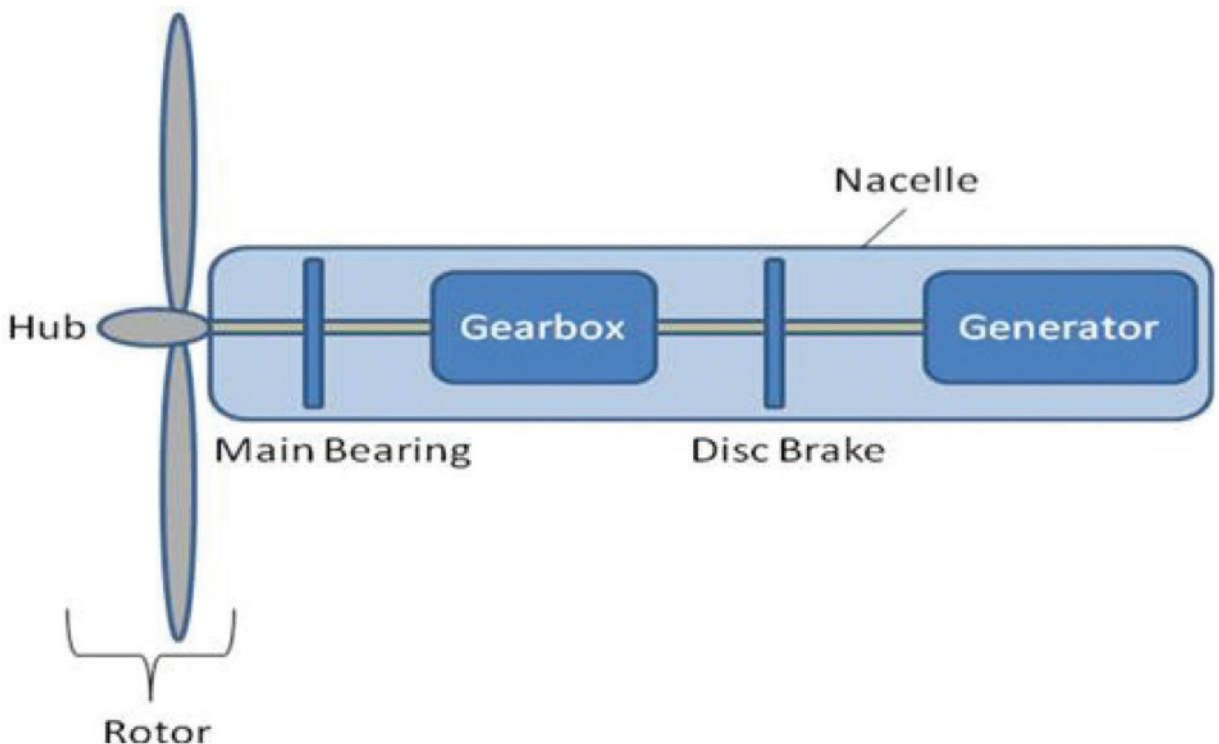


Figure 1: The major components of a wind turbine.

3 as a model of the turbine's interaction with the wind. This diagram indicates that wind exists on either side of the turbine, and the proper balance between rotational speed and the velocity of wind are critical to regulate performance. The balance between rotational speed and wind velocity, referred to as the tip speed ratio, is calculated using Equation 1.

$$\lambda = \frac{2\pi fr}{v_1}$$

Equation 1: Calculating the tip speed ratio.

Where: f is the blades frequency of rotation (Hz)
 r is the length of a blade (m)

The efficiency of a wind turbine is called the power coefficient, or C_p . Theoretically, the power coefficient is calculated as the ratio of actual to ideal extracted power. You can find this calculation in Equation 2. Also, you can adjust C_p by controlling the angle of attack, α , and the tip speed ratio, λ . The calculation for this case is shown in Equation 3. In Equation 3, c_1 , c_6 and x are coefficients that the wind-turbine manufacturer should provide. Note that the maximum power coefficient that you can achieve with any turbine is 0.59, or the Betz limit.

$$C_p = \frac{P_{actual}}{P_{ideal}} = \frac{.25\rho A(v_1^2 - v_2^2)(v_1 + v_2)}{.5\rho A v_1^3}$$

Equation 2: The power coefficient is calculated as the ratio of actual to ideal extracted power.

$$C_p(\lambda, \alpha) = c_1 \left(c_2 \frac{1}{\lambda} - c_3 \alpha - c_4 \alpha^x - c_5 \right) e^{-c_6 \frac{1}{\lambda}}$$

$$\frac{1}{\lambda} = \frac{1}{\lambda + .08\alpha} - \frac{.035}{1 + \alpha^3}$$

Equation 3: You can adjust the C_p by controlling the angle of attack, α , and the tip speed ratio.

Finally, you can calculate the usable power from the wind using Equation 4. From this equation, you can see that the main drivers for usable power are the blade length and wind speed.

$$P = \frac{C_p(\lambda, \alpha) \rho \pi r^2 v_1^3}{2}$$

Equation 4: Calculating usable power from the wind.

Where: ρ = density of air (1.2929 kg/m³)

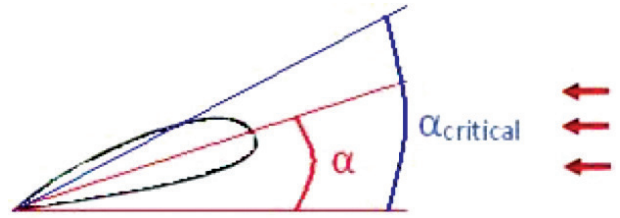


Figure 2: The critical angle of attack ($\alpha_{critical}$) with respect to the blade.

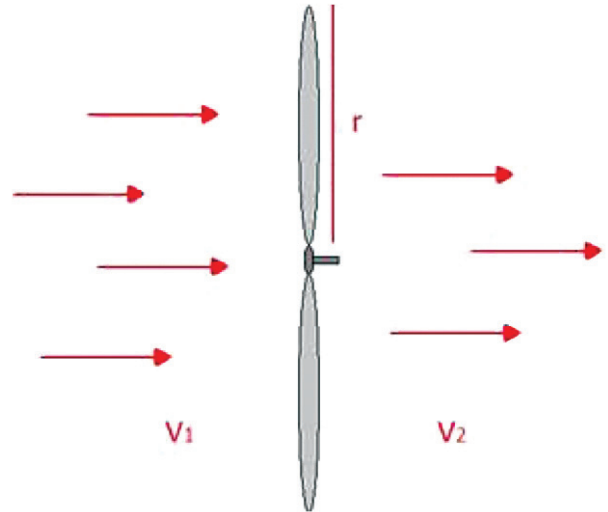


Figure 3: Model of the turbine's interaction with the wind.

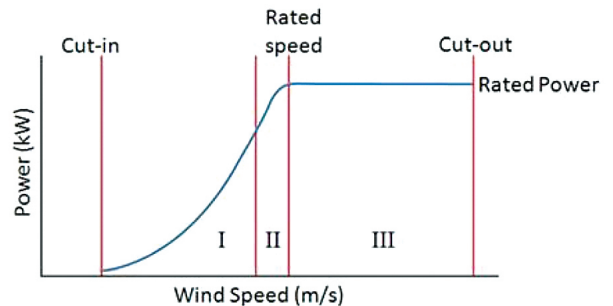


Figure 4: Ideal wind turbine power curve.

THE POWER CURVE

It is important to understand the relationship between power and wind speed to determine the required control type, optimization, or limitation. The power curve, a plot you can use for this purpose, specifies how much power you can extract from the incoming wind. Figure 4 contains an ideal wind-turbine power curve.

The cut-in and cut-out speeds are the operating limits of the turbine. By staying in this range, you ensure that the available energy is above the minimum threshold and structural health is maintained. The rated power, a point



Figure 5: Pitch adjustment.

provided by the manufacturer, takes both energy and cost into consideration. Also, the rated wind speed is chosen because speeds above this point are rare. Typically, you can assume that a turbine design that extracts the bulk of energy above the rated wind speed is not cost-effective.

From Figure 4, you can see the power curve is split into three distinct regions. Because Region I consists of low wind speeds and is below the rated turbine power, the turbine is run at the maximum efficiency to extract all power. In other words, the turbine controls with optimization in mind. On the other hand, Region III consists of high wind speeds and is at the rated turbine power. The turbine then controls with limitation of the generated power in mind when operating in this region. Finally, Region II is a transition region mainly concerned with keeping rotor torque and noise low.

CONTROL METHODS

You can use different control methods to either optimize or limit power output. You can control a turbine by controlling the generator speed, blade angle adjustment, and rotation of the entire wind turbine. Blade angle adjustment and turbine rotation are also known as pitch and yaw control, respectively. A visual representation of pitch and yaw adjustment is shown in Figures 5 and 6.

The purpose of pitch control is to maintain the optimum blade angle to achieve certain rotor speeds or power output.

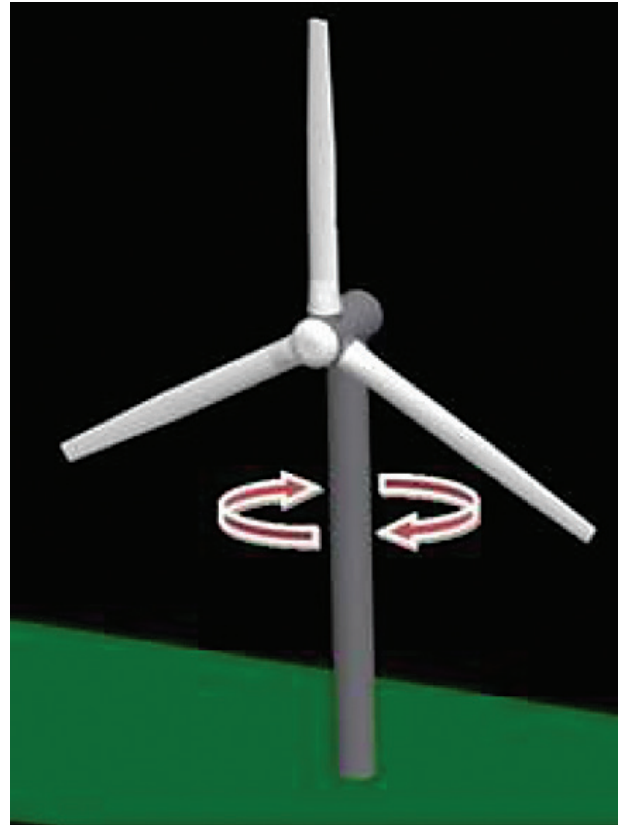


Figure 6: Yaw adjustment.

You can use pitch adjustment to stall and furl, two methods of pitch control. By stalling a wind turbine, you increase the angle of attack, which causes the flat side of the blade to face further into the wind. Furling decreases the angle of attack, causing the edge of the blade to face the oncoming wind. Pitch angle adjustment is the most effective way to limit output power by changing aerodynamic force on the blade at high wind speeds.

Yaw refers to the rotation of the entire wind turbine in the horizontal axis. Yaw control ensures that the turbine is constantly facing into the wind to maximize the effective rotor area and, as a result, power. Because wind direction can vary quickly, the turbine may misalign with the oncoming wind and cause power output losses. You can approximate these losses with Equation 5:

$$\Delta P = \alpha \cos(\epsilon)$$

Equation 5

Where ΔP is the lost power and ϵ is the yaw error angle.

The final type of control deals with the electrical sub-system. You can achieve this dynamic control with power electronics, or, more specifically, electronic converters that are coupled to the generator. The two types of generator control are stator and rotor. The stator and rotor are the

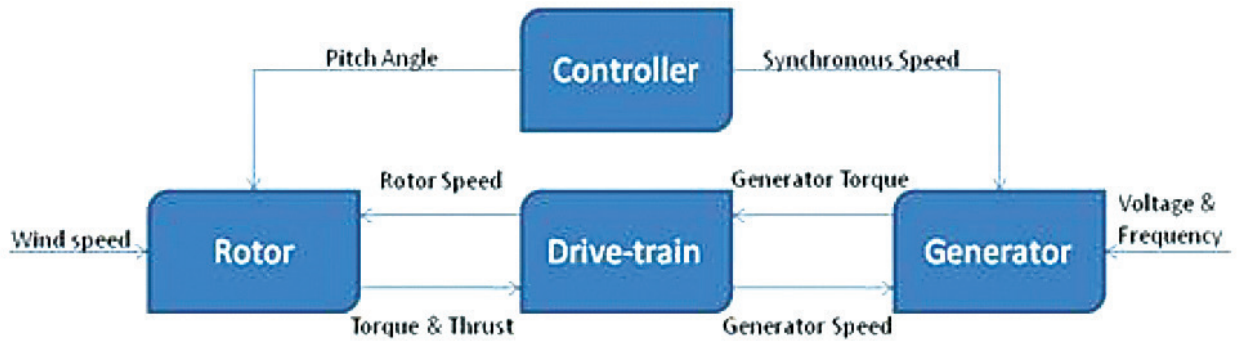


Figure 7: System-level layout of a wind-energy system.

stationary and nonstationary parts of a generator, respectively. In each case, you disconnect the stator or rotor from the grid to change the synchronous speed of the generator independently of the voltage or frequency of the grid. Controlling the synchronous generator speed is the most effective way to optimize maximum power output at low wind speeds.

Figure 7 shows a system-level layout of a wind energy conversion system and the signals used. Notice that control is most effective by adjusting pitch angle and controlling the synchronous speed of the generator.

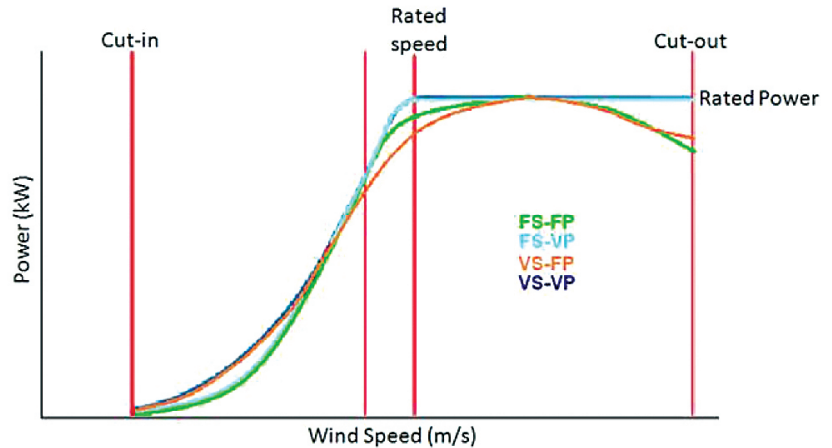


Figure 8: Power curves for different control strategies (variable-speed variable-pitch, VS-VP, is the ideal curve.)

CONTROL STRATEGIES

Recall that controlling the pitch of the blade and speed of the generator are the most effective methods to adjust output power. The following control strategies use pitch and generator speed control to manage turbine functionality throughout the power curve: fixed-speed fixed-pitch, fixed-speed variable-pitch, variable-speed fixed-pitch, and variable-speed variable-pitch. Figure 8 shows the power curves for different control strategies explained below, with variable-speed variable-pitch, VS-VP, being the ideal curve.

Fixed-speed fixed-pitch (FS-FP) is the one configuration where it is impossible to improve performance with active control. In this design, the turbine's generator is directly coupled to the power grid, causing the generator speed to lock to the power line frequency and fix the rotational speed. These turbines are regulated using passive stall methods at high wind speeds. The gearbox ratio selection becomes important for this passive control because it ensures that the rated power is not exceeded. Figure 8 shows the power curve for FS-FP operation.

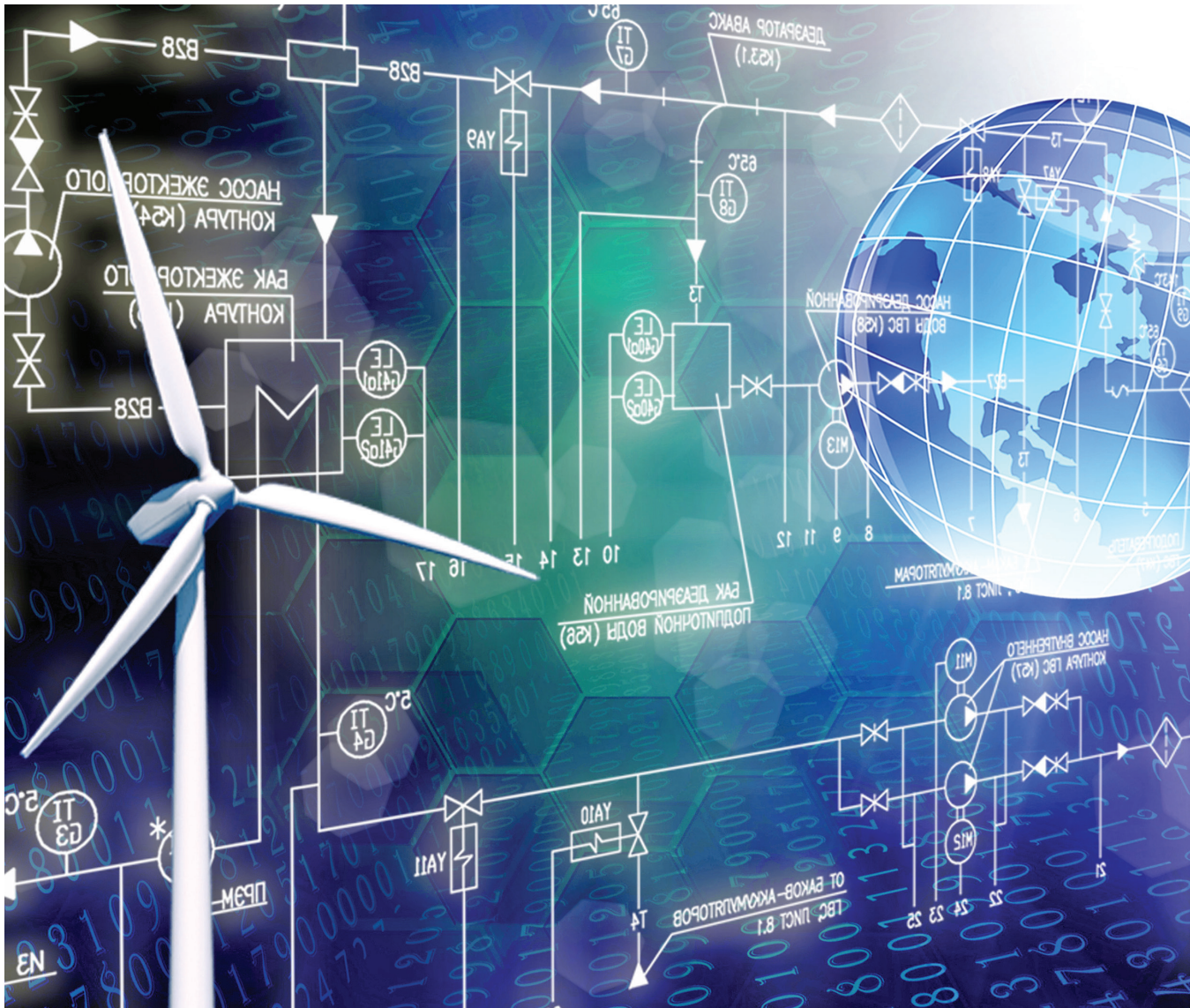
From the figure, it is apparent that the actual power does not match the ideal power, implying that there is lower energy capture. Notice that the turbine operates at maximum efficiency only at one wind speed in the low-speed region.

The rated power of the turbine is achieved only at one wind speed as well. This implies poor power regulation as a result of constrained operations.

Fixed-speed variable-pitch (FS-VP) configuration operates at a fixed pitch angle below the rated wind speed and continuously adjusts the angle above the rated wind speed. To clarify, fixed-speed operation implies a maximum output power at one wind speed. You can use both feather and stall pitch control methods in this configuration to limit power. Keep in mind that feathering takes a significant amount of control design and stalling increases unwanted thrust force as stall increases. Figure 8 shows the power curve for FS-VP using either feather or stall control.

Below the rated wind speed, the FS-VP turbine has a near optimum efficiency around Region II. Exceeding the rated wind speed, the pitch angles are continuously changed, providing little to no loss in power.

Variable-speed fixed-pitch (VS-FP) configuration continuously adjusts the rotor speed relative to the wind speed through power electronics controlling the synchronous speed of the generator. This type of control assumes that the generator is from the grid so that the generator's rotor and drive-train are free to rotate independently of grid frequency. Fixed-pitch relies heavily on the blade design to



limit power through passive stalling. Figure 8 shows the power curve for VS-FP.

Figure 8 shows that power efficiency is maximized at low wind speeds, and you can achieve rated turbine power only at one wind speed. Passive stall regulation plays a major role in not achieving the rated power and can be attributed to poor power regulation above the rated wind speed. In lower wind speed cases, VS-FP can capture more energy and improve power quality.

Variable-speed variable-pitch (VS-VP) configuration is a derivation of VS-FP and FS-VP. Operating below the rated wind speed, variable speed and fixed pitch are used to maximize energy capture and increase power quality. Operating above the rated wind speed, fixed speed and variable pitch permit efficient power regulation at the rated power. VS-VP is the only control strategy that theoretically achieves the ideal power curve shown in Figure 8.

SUMMARY

This article covered some essential wind energy concepts, such as the angle of attack and the power coefficient, as well as different control methods and strategies. Pitch, yaw, and rotational speed control were the main control methods used to optimize or limit the power extracted from the wind. Wind-turbine control is essential for optimal performance, safe operation, and structural stability. ✎

ABOUT THE COMPANY

For more than 40 years, NI has developed automated test and automated measurement systems that help engineers solve the world's toughest challenges. This article appears courtesy of NI. It has been edited to conform to the style of Wind Systems magazine. The original article can be found at www.ni.com/en-us/innovations/white-papers/08/wind-turbine-control-methods.html

Scott Bryan

Vice President – Wind Division ▀ World Wind & Solar



“If a client requests trained labor on a site for a specific need or to perform scheduled maintenances or large corrective composite services, we are ready to serve.”

▀ **What does World Wind & Solar (WWS) bring to the wind energy table, and what is your role with the company?**

World Wind & Solar (WWS) brings a full life cycle range of comprehensive service solutions to all our renewable energy clients across the nation. We can provide end-to-end services in any stage or phase of a project, from construction and commissioning to operations and maintenance to repowering and decommissioning.

Our team of professionals also provide specialized support. If a client requests trained labor on a site for a specific need or to perform scheduled maintenances or large corrective composite services, we are ready to serve.

As part of our full life cycle service offerings, we provide engineering services, which is something not offered by other independent service providers (ISPs). Our team of engineers and field service engineers can tackle any problem, even when it seems nearly impossible.

We have spare parts, kitting, and logistics capabilities at our new 32,000-square-foot warehouse in Elgin, Illinois. We can provide individual components to our clients on an as-needed basis, or we can provide pre-packaged supply kits that include all the necessary greases, oils, and other PM supplies. Our turn-key logistical service will ship these kits to all their projects across the US.

With these new services, we're truly an end-to-end solutions provider for our renewable energy clients.

WWS provides services for wind, solar, EV charging, and energy storage. As vice president of Wind, I oversee and manage all wind-service offers to ensure we are providing safe, professional, and efficient specialized services to our clients.

▀ **What types of wind services have you recently added?**

In the last year, we've added a large correctives team, a com-

posites team, engineering support, and our distribution and supply chain center. Our newest services include gearbox exchanges, blade exchanges, and blade and composite repair. And we have plans to expand our services further this year as well.

▀ **What drove the need for the additions?**

Providing the best services at the best value for our clients has always been our focus. We strive to be a dedicated and transparent extension of our client's team. By expanding our service offerings to cover everything from troubleshooting to blade repairs, logistics and supply chain, to engineering services, we are their end-to-end solutions provider and truthfully, that is the best way we can add value.

▀ **What's been the industry response to the new services?**

The industry has welcomed our new services and supply chain capabilities. We've worked with a variety of clients on large corrective and blade repair projects. We've been steadily building our parts inventory and have been able to assist several clients with their supply chain needs. We are very pleased with the teams we've built and the progress we've made.

▀ **How has the pandemic changed the way you work with the wind farms and their owners?**

As a mission-critical service provider, we have had to make some adjustments to protect our employees and customers. The health and safety of our technicians is our top priority, so in addition to staying up to date on local, state, and federal recommendations for masks, hand washing, social distancing, and daily health checks, we've implemented our own process and procedural changes.

To reduce individual contact exposure, we're utilizing split shifts and split crews, using more electronic communi-



World Wind & Solar's newest services include gearbox exchanges, blade exchanges, and blade and composite repair. (Courtesy: World Wind & Solar)

cation methods such as texts and emails, and even changing how we distribute supplies to our crews.

We also work with our clients to ensure our safety modifications align with their policies and with industry best practices.

► **I would imagine the remote aspect of the technician job helps a little bit with the social distancing.**

It does help, but our wind turbine technicians work in teams of at least two, if not more. So, we have focused on keeping the same team members together and limiting travel as much as we can. This has also made it a challenge for our management teams to get out to the field for project site visits.

► **With an administration now in place that favors the advancement of renewables, do you see World Wind & Solar's workload growing over the next few years with that in place?**

A pro-renewables administration can certainly be helpful, but we've seen growth regardless, which is why we've made the heavy investment in new services and capabilities. We believe the renewable energy industry will continue to grow and we plan to grow right along with it.

► **There's been a shift from federal support to more state and local and privatized support that's helped move renewables forward. Do you see that as well?**

We've seen the renewable energy industry continue to grow, even though many of the federal subsidies have decreased over time. The rate of new renewable energy projects going online far exceeds those of fossil fuels.

Being an end-to-end solutions provider, maintaining our nation's critical infrastructure, means we're ready to support new construction growth as well as being able to keep our current, aging equipment operating efficiently.

And there are many fleets, a critical mass, that are 10 and 15 years old.

► **What's your take on what happened in Texas in February?**

I've been in wind for 12 years now and have managed farms from Canada to the Oregon coast — all kinds of climate at all times of the year. What happened in Texas is unprecedented, but quite simply their machines were not prepared for it.

Most turbines are certified for anywhere between minus-20°C and minus-30°C. And depending on where a turbine is purchased, it could have a winter package that would include things like additional heaters.

But air temperature isn't always the problem. If temperatures are extremely cold and there's no wind to keep the turbine working, it will become cold-soaked in a day or two. When the wind picks back up, the turbine may fault. If the turbine had been running, even in extreme temps, it would typically continue to run with no problem. It's similar to your car. If it sits out in minus-30° weather for a few days, it will have a hard time starting or not start at all. A turbine, similar to a car, has electrical and hydraulic components that can freeze once idle.

There can also be an issue with icing. Although icing doesn't usually affect all the turbines at a project, and it is very dependent on individual power plants, their location, and wind and weather patterns.

Once a turbine is cold-soaked, intervention can be needed to start up. WWS had crews in these regions, working with our customers, supporting them to get everything up and running.

WWS is always there, when and where our customers need us. ✈

MORE INFO ► www.WorldWindSolar.com



Ingeteam is fully committed to meeting the challenges of the rapidly expanding global wind power market. (Courtesy: Ingeteam)

INNOVATION

Ingeteam strengthens tech platforms to meet future challenges

Ingeteam Wind Energy, a global specialist in wind-energy drivetrain technology, announced that it has successfully secured framework contracts with key clients for the serial supply of its latest technology developments, including its new high power DFIG converters, as well as low- and medium-voltage full power converters. These agreements will secure the manufacture and supply of new generation and conversion equipment across its manufacturing plants in 2021 and beyond.

Ingeteam is fully committed to meeting the challenges of the rapidly expanding global wind power market, to promote the implementation of international quality standards as defined by the APQP4Wind manual for the development of wind products, and to optimize the LCOE. This is an evolutionary process, based on continuous improvement, to increase competitiveness, and reduce costs to facilitate the transition to renewable energies around the world.

Since first launching its DFIG converters 25 years ago, this technology has become the standard for the onshore wind turbines. 2020 saw the launch of Ingeteam's latest generation of wind-energy converters developed for high-power DFIG converters,

expanding the range from 5 MW to between 6 and 8 MW. These doubly fed converters with high-speed drivetrain technology have been rigorously tested and labeled to comply with the strictest international grid codes and facilitate the full wind-turbine certification process.

For offshore markets, LCOE optimization has typically been achieved through the development of ever larger wind turbines.

"Offshore wind turbines, with capacities of 10 MW and above, will move from prototype stage to commercial availability in the short-term," said Alberto Barcia, commercial director of Ingeteam's Wind Business. "We are working closely with manufacturers to bring these huge machines to mar-

ket, by developing a third-generation suite of medium-voltage (MV) full converters, which offers a range of benefits to OEMs. Their compact and modular design provides flexibility to adapt to power upgrades, and they are more easily installed within nacelles. MV converters are able to achieve optimized availability and reduce maintenance, both critical conditions for offshore wind farms.”

Power plant control and monitoring is also at the heart of Ingeteam’s business to optimize LCOE. The development and implementation of a Renewable Energy Control Center offered in the Smart SCADA suite of solutions integrates big data analytics and cybersecurity ensuring safe and comprehensive control of renewable assets. By offering flexibility in design, backed by R&D, the company provides clients with tailored and competitive solutions to minimize LCOE and optimize their equipment. In 2020, an increasing number of clients entrusted Ingeteam to develop their own control centers, demonstrating the success of the technology and Ingeteam’s client focused approach.

During a year in which the global COVID-19 pandemic has created unprecedented disruption, affecting many lives and businesses, Ingeteam is proud of the accomplishments of all its employees, providing high-quality service to clients around the world. A constant rhythm of activity has been maintained at all manufacturing plants. In total, the company delivered 3 GW of electrical equipment to wind OEMs, confirming its market leadership position.

“Our agile and localized manufacturing strategy allows for the flexible supply of products and solutions, including the new generation of equipment in all technologies, from our cutting-edge manufacturing facilities in Europe, Asia, and North and South America, to the highest quality standards in the market,” Barcia said.

MORE INFO www.ingetteam.com

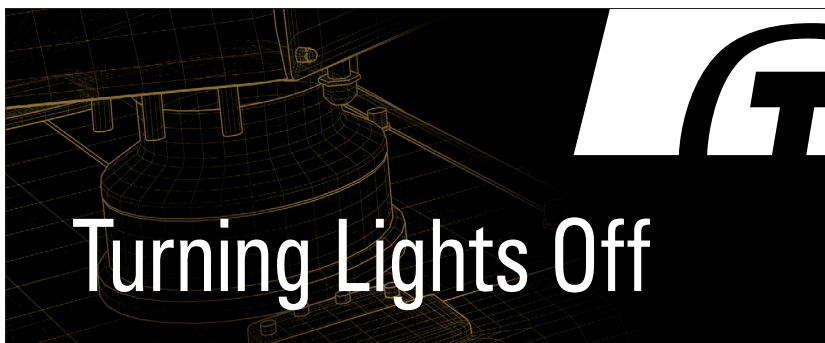
INNOVATION

B&K Vibro introduces machine health monitoring tech

Brüel & Kjær Vibro (B&K Vibro), one of the leading worldwide independent

suppliers of condition monitoring solutions for rotating machinery, has launched VIBROSTORE 100, a palm-sized device that provides vibration level and bearing wear monitoring for balance-of-plant machines at the push of a button.

The lightweight device can be used single-handedly and enables even un-



Terma’s Aircraft Detection Lighting System (ADLS) vastly reduces the impact of Aviation Obstruction Lights on local wildlife and communities while preserving the dark skies

- FAA and FCC compliant
- Scalable and cost-effective
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trained personnel to take vibration measurements and assess a semi-critical machine's overall vibration condition. The instrument is equipped with a pre-set cable-connected high-quality B&K Vibro acceleration sensor. Once the type and size of the machine based on ISO 10816 and its running speed are entered, a one-button push can perform the measurement. A traffic-light display immediately indicates the severity of the vibration based on the built-in ISO 10816 alarm limits (velocity in mm/s or in/s). The main screen also shows the rolling-element bearing condition in bearing damage units measurement (BDU) and total g (RMS acceleration). The display of the vibration level in frequency ranges indicates the most common machine faults, such as imbalance, misalignment, or looseness.

"Whereas critical and semi-critical machinery is usually equipped with an online protection system to avoid catastrophic damages, it is often too difficult and costly to install an online condition monitoring system on every semi-critical machine," said Florian

Endres, commercial platform leader, B&K Vibro. "With a combination of B&K Vibro quality and extremely competitive pricing, the VIBROSTORE 100 fills the gap in detecting the most common machine faults and delivers quick, reliable and cost-efficient machine health monitoring for semi-critical and balance-of-plant machines."

VIBROSTORE 100 is available either as stand-alone or packaged with the B&K Vibro Report & Route Manager software, a powerful and highly functional route editor and analysis software.

MORE INFO www.bkvibro.com/vibrostore-100

INNOVATION

New lifting system, tower to enhance turbine assembly

Mammoet has started a joint effort with Sumitomo Mitsui Construc-



A new lifting system allows the nacelle to be affixed to each turbine tower at a much lower height. (Courtesy: Mammoet)

tion Co., Ltd and FHECOR Ingenieros Consultores for the development of an innovative onshore wind-turbine generator erection system and tower structure. Its self-climbing installation technology erects each wind turbine tower in sections, allowing them to reach to greater heights and more reliable winds.

As nations strive toward 2050 carbon neutrality targets set by the Paris Agreement, onshore wind is seen as a reliable and plentiful source of renewable energy. Installation onshore brings access to stronger and more constant air flows; at higher hub heights this effect is multiplied.

However, as towers stretch toward 200 meters, fewer cranes have the reach necessary to perform turbine assembly on land. Developers then looked at alternative assembly methodologies such as climbing cranes or huge tower cranes, but these are not available in the market. In addition, other massive crawler cranes used are not specifically designed for onshore wind-farm constructions.

Furthermore, when towers approach 200 meters in height, there is an additional requirement for them to be constructed using a concrete or hybrid steel-concrete structure because steel alone lacks the rigidity required to support the weight of the tower, nacelle, and blades.

To address the above challenges, Mammoet, Sumitomo Mitsui Construction, and FHECOR have agreed to start the joint development of a 200-meter tower. The design was by both Sumitomo Mitsui Construction



The VIBROSTORE 100 can be used single-handedly and enables even untrained personnel to take vibration measurements. (Courtesy: B&K Vibro)

and FHECOR whereas the self-climbing lifting system's conceptual design was by Sumitomo Mitsui Construction. Mammoet contributed in terms of experience and engineering. Each tower is to be constructed in sections and raised in stages to its full operational height.

This system allows the nacelle to be affixed to each turbine tower at a much lower height than is the case, improving the safety of each lift and allowing customers to choose from a larger pool of cranes that is capable of undertaking this work. In turn, this has a positive impact on both project scheduling and cost.

It will also allow turbine blades to be connected to the nacelle at a lower height and ensure that equipment in use for onshore wind projects does not need to be replaced as hub heights grow.

"With Mammoet, this project moves from concept to reality," said a representative of Sumitomo Mitsui Construction. "We provided technical development for design and ideation, whereas Mammoet then supporting us with their experience and expertise in heavy lifting and engineering for wind-power and renewables sector. We believe this technology developed will meet gradually also meet the needs of onshore and offshore wind markets not just in Japan, but around the world."

The technology can be used for

both greenfield onshore, offshore wind developments, or for the renewal of existing onshore wind towers. Development of the technology continues.

MORE INFO www.mammoet.com

INNOVATION

WindCube advances wind energy with enhancements

Leosphere, a Vaisala company that specializes in developing, manufacturing, and servicing turnkey wind Lidar instruments for wind energy, recently announced increased measurement capabilities, premium services, and turnkey options for WindCube® — the industry-standard vertical profiling Lidar for wind energy applications — to further deliver an unprecedented customer experience.

"With renewable energy technologies continuing to advance and proliferate, wind-power generation is set to take off in an increasing number of geographies around the globe," said David Pepy, head of Renewable Energy Business, Leosphere. "To maximize efficiency and production, a complete, accurate view of the wind profile is essential — particularly as wind turbines become increasingly larger, especially offshore. These lat-



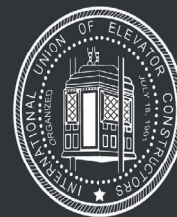
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WindCube's new set of enhancements provide increased performance. (Courtesy: Leosphere)

est WindCube enhancements provide that. Just as critical, our new services, including a suite of validation options through our partnership with DNV GL, will increase Lidar operational continuity and maximize uptime. Combined, these new improvements empower wind-farm developers and operators to harness the power of wind energy more quickly, efficiently, and affordably.”

WindCube’s new set of enhancements provide increased performance. The benefits of these enhancements include:

Innovative new algorithm: The system embeds a unique hybrid wind reconstruction algorithm to reach an unrivaled IEC classification while reducing uncertainty and increasing reliability.

Increased wind-measurement range and more simultaneous measurement heights: By measuring up to 300 meters at 20 simultaneous heights, WindCube comfortably covers the wind profile of even the largest onshore and offshore wind turbines, providing increasingly accurate and reliable data for wind-resource campaigns.

Industry-standard compliance: Validated by Deutsche Windguard, WindCube is IEC-classified and compliant with the highest-available industry standards.

Improved service levels: Accelerated workshop service and a premium service level with on-site repair and guaranteed intervention delays maximizes uptime and service continuity.

Turnkey options: Affordable new options simplify deployment and operation, with additional options to come soon.

A suite of new validation services, through a partnership with DNV GL, a global quality assurance and risk management company that delivers advisory, certification, and testing services to stakeholders in the energy value chain — maximizes uptime and simplifies third-party validations, saving organizations time and money. These services include:

WindCube Golden Validation by DNV GL: Each WindCube is validated

by DNV GL against a Golden Lidar before it leaves the factory.

IEC-Compliant Validation by DNV GL: With this option, fully IEC-compliant WindCube Lidars can be ordered and delivered, shaving approximately two months from the third-party, on-site validation process. This enables the Lidar to enter service quickly while fulfilling standards’ requirements for bankable wind resource measurement and power-performance validation.

Validation Continuity to Maintain IEC Compliance: By providing a unique DNV GL-validated Laser Chain swap process in case of maintenance, this optional warranty service — which is estimated to be available by end of the first quarter of 2021 — ensures the system automatically maintains IEC-compliant validation by DNV GL during maintenance and can be immediately put back into service.

“Our partnership with Leosphere will provide the industry with unique services that will save their customers time and money,” said Fabio Wagner, head of Section Loads & Power Performance & Wind Resource at DNV GL.

“We’ve reviewed already more than 45 of the enhanced WindCube Lidars and can conclude that WindCube meets the highest standards for accuracy,” said Bastian Schmidt, Remote Sensing Team Leader at DNV GL. “The

improvement of the wind-reconstruction algorithm surely has the potential to help with bankability and measurement accuracy.”

With more than 15 years of scientific Lidar innovation, WindCube has earned the trust of customers and other industry leaders through thousands of deployments around the globe.

MORE INFO www.windcubelidar.com

CONSTRUCTION

Swedish take-up of the Siemens Gamesa 5.X platform continues

The strength of the onshore powerhouse Siemens Gamesa 5.X platform has gathered momentum in Sweden heading into 2021 following the signing of a 62 MW deal to supply two adjacent sites in the Sunne region.

The deal with local utility firm Tekniska verken will cover the supply of 7 SG 5.8-170 turbines at Fryksdalshöjden and three of the same turbines at the nearby site of Norra Länsmansberget. These turbines will use a flexible power rating to adjust their nominal power to 6.2 MW, among the most competitive in the industry. They are



The deal with local utility firm Tekniska verken will cover the supply of 7 SG 5.8-170 turbines at Fryksdalshöjden and three of the same turbines at the nearby site of Norra Länsmansberget. (Courtesy: Siemens Gamesa)

expected to be installed by late 2022 and will have a 115-meter hub height. The deal also includes a up to 30-year service agreement.

Siemens Gamesa has now sold more than 2 GW of this market leading on-shore platform with one of the largest rotors at 170 meters in the industry, enabling it to provide an unrivaled leveled cost of energy (LCOE). Of that 2 GW, about half has come from various sites and customers in Sweden, showing the pioneering nature of the country and its enterprises in their adoption of renewable technology.

"Sweden has proven a major driver to the success of the Siemens Gamesa 5.X platform, and we are encouraged to see its rapid roll-out continue in 2021," said Clark MacFarlane, Siemens Gamesa Onshore CEO for Northern Europe. "We also welcome another contract with a key customer in Tekniska verken, with which we will work closely going forward to help develop the region's renewable capabilities."

"Our choice of turbines is based on sustainability in the long term with the least possible impact on the environment," said Tekniska verken i Linköping Vind AB CEO Henrik Valent. "We always strive to create solutions that are beneficial to society, the environment, and the economy. Today we are glad to say that the SG 5.8-170 turbine fits our two projects perfectly."

Siemens Gamesa's contracts in Sweden for this latest platform also included a huge 372 MW deal in Björnberget, the largest it has signed in the country for the 5.X turbine.

MORE INFO www.siemensgamesa.com

CONSTRUCTION

Offshore leader Mark Rogers joins Burns & McDonnell

Burns & McDonnell has hired industry veteran Mark Rogers to lead the firm's development of offshore substations for offshore wind-farm projects in



Mark Rogers (Courtesy: Burns & McDonnell)

the U.S. With the addition of Rogers, Burns & McDonnell is now capable of providing the complete electrical system design for offshore wind farm projects.

"We believe the offshore wind industry in the U.S. has potential to help create thousands of high-paying jobs, support a growing economy, and help us to create efficient, sustainable energy for years to come," said Ray Kowalik, chairman and CEO of Burns & McDonnell. "To support the development of offshore wind farms in the Northeast, our firm plans to grow 15 percent to 20 percent each year in the region throughout the next five years. Mark is a big part of that as he brings his European experience to the emerging U.S. market."

An engineering manager with more than 35 years of experience in offshore and onshore electric transmission and power generation, Rogers will serve as the offshore substation engineering manager for the firm. Most recently, Rogers led the offshore platform engineering team at one of the largest global technology firms, developing a portfolio of offshore substation platforms for more than 3 GW of offshore wind in Europe.

Rogers will work to train and mentor Burns & McDonnell engineers in



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the U.S. and hire additional electrical engineers to expand knowledge of offshore substations and share his experience from the European market.

“Mark has created innovative market-leading solutions that have shaped the offshore wind industry,” said Jason Cabral, Northeast U.S. regional vice president for Burns & McDonnell. “With Mark’s industry knowledge, our firm will be able to execute the electrical components of offshore wind projects in the U.S. from the turbine to the interconnecting utility, using the services and skill sets required to design and manage the complex and expansive needs of offshore wind projects.”

While the offshore wind market is in the early stages in North America, Burns & McDonnell is engaged in work on approximately 80 percent of the announced projects. The firm’s involvement includes services for new and updated onshore substations, overhead/underground transmission lines including HDDs and transition join bays, offshore export cables with voltages from 66-kV to 275-kV, interconnection stations with voltages from 69-kV to 345-kV, HVDC converter stations, and station ratings from approximately 100 to 900 MW. The firm has undertaken interconnection studies, system analysis reviews, grid connection analyses, harmonic measurements, permitting, overall project management, FEED packages and bid development support.

MORE INFO www.burnsmcd.com

MAINTENANCE

WWS delivers blade, composite repair service

As part of its long-term growth strategy, World Wind & Solar (WWS), a Pearce Services Company and a leader in repair and maintenance services for commercial and utility-scale renewable Wind, Solar, and Energy Storage System (ESS) assets, recently announced a new capability to provide blade and composite repair services to customers that own and operate wind-power assets.

Regarding WWS Blade and Composite Repair services, Vice President of Wind Services Scott Bryan, said, “World Wind & Solar has a great reputation for quality, safety, and services. Following our acquisition by Pearce Services, we enhanced our focus and investments into broadening the specialized services we provide for our customers. Having a team of technicians and field service engineers solely focused on blade and composite repairs means that WWS is truly a one-stop shop for any and all services required on a wind or solar farm.”

WWS is now offering these new services across the nation:

- Full blade and composite repair services, including blade inspection, leading edge repair/upgrade, vortex generator installation, lightning strike repair, and major structural repair.

- Field service engineering support for specialized composite repairs

and blade inspections.

- Specialized lifts to enable safe, effective, and efficient repairs.

- A team of highly trained, elite technicians with 10-plus years of industry experience.

- Full composites supply chain and inventory management capabilities from WWS’ 32,000-square-foot warehouse just outside Chicago, Illinois.

In March 2020, WWS was acquired by Pearce Services, which reinforced its mission as an independent service provider for critical infrastructure in the renewable energy industry.

“The growth of our team at WWS and our industry has been extraordinary this year,” said Mark McLanahan, the leader of the renewables division for Pearce Services. “Our integration with Pearce Services and the alignment in our mission to safely service our customers has made our platform stronger than ever and well-positioned to meet our customers’ expanding needs with these new technical capabilities.”

Each year, WWS has met the rapid growth of the industry by enhancing its service capabilities and growing its team. With more than 500 technicians now working in the field, WWS works to serve its OEM, owner, and operator customers with an elite workforce. These new wind technical services are a natural evolution in the company’s ability to serve a diverse set of customers and extend the career path for its professionals. Furthermore, in-house technical training programs have been developed to ensure technicians safety, while efficiently and expertly delivering results in the field.

MORE INFO www.worldwindsolar.com

MAINTENANCE

ONYX signs contract with Japan’s largest wind-farm owner

ONYX InSight, a leading provider of data analytics and engineering exper-



World Wind & Solar offers blade and composite repair services to customers that own and operate wind-power assets. (Courtesy: WWS)



ONYX InSight's ecoCMS condition monitoring systems (CMS) will monitor drive train performance in multiple turbine models across the two Japanese wind farms. (Courtesy: Eurus)

tise to the global wind industry, has been selected by Eurus to monitor and analyze the health and performance of 33 wind turbines at two wind farms in Japan. Following a competitive tender, ONYX InSight and Eurus have agreed a two-year predictive maintenance contract covering 59 MW of the Japanese developer's portfolio. Under the contract, ONYX InSight began installing 33 ecoCMS monitoring systems in August 2019.

ONYX InSight's ecoCMS condition monitoring systems (CMS) will monitor drive train performance in multiple turbine models across the wind farms. The innovative system uses Micro-Electro Mechanical Systems (MEMS) technology to increase coverage of sensors on the drive train. Coupled with IoT technology, ONYX InSight's ecoCMS monitoring equipment empowers operators to re-evaluate the real-life costs of CMS and helps them reap the benefits of online monitoring and predictive maintenance.

The ecoCMS hardware will be coupled with fleetMONITOR, ONYX InSight's monitoring software, to analyze the performance and health data across the turbines. Cloud-based fleetMONITOR will enable Eurus to constantly track the health and performance of all the turbines with ecoCMS installed and provide early failure detection to support strategic predictive maintenance decisions.

By investing in robust and reliable predictive maintenance technolo-

gy and monitoring services, Eurus strengthens its potential for O&M cost savings. By monitoring and analyzing turbine data from the ecoCMS technology over two years, ONYX InSight will help Eurus to make significant O&M cost savings across the monitored wind turbines.

Japan is making strides toward nurturing the growth of wind energy in the region. The consultancy Institute for Energy Economics & Financial Analysis identified in a 2017 report that there is the potential for 10 GW of offshore wind in Japan by 2030. If the Japanese government maintains its commitment to support offshore wind, the country is set to become one of the most promising markets for the sector over the next decade.

This means that asset owners and operators will increasingly be looking to reduce O&M costs, while maximizing asset availability and profitability, as investors look to optimize their return-on-investment (ROI) to reflect the profitability of the European wind industry.

"By adopting predictive maintenance technologies, Eurus has positioned itself as a market leader in Japanese wind," said Noah Myrent, Global Head of Monitoring, ONYX InSight. "Eurus will benefit from being one step ahead in an increasingly digital market, allowing the company to better manage operational budgets and improve turbine performance."

MORE INFO www.onyxinsight.com

► MANUFACTURING

GRTC's new turbine can be used as mobile power station

Fort Myers, Florida-based Golden Ratio Turbine Concepts (GRTC), a pioneering Golden Ratio rotary device creator, has built a new Golden Ratio Turbine. The new prototype is the most recent in the company's "CYCLOTROSS™" line of vertical axis wind turbines (VAWT),

and it reveals a new innovative golden spiral wing design.

GRTC spokesman James Walker said the company's previous smaller prototype success had prompted the development of a larger device that could be trailer-mounted and transported to remote areas as a temporary or prolonged power station. The VAWT has at its core a 1 KW-3 phase AC axial flux PMG generator and incorporates an intelligent 48-volt hybrid wind/solar AC/DC power converter/controller. The power load center compartment is in the rear of the trailer and houses the 4-deep cycle, 12-volt storage batteries along with the charge controller, a pure sinewave DC to 120 volt AC inverter, and the 3-cup anemometer wind speed display electronics.

As well as the 120-volt 60-cycle AC output, the station provides 12- and 24-volt DC ports for accessories and charging needs. The hybrid controller enables the combined inputs of a solar array and the new VAWT to provide clean power anywhere the sun shines and the wind blows (even on a floating barge or a mountain top), all of which creates a versatile new electrical power generator station that is adaptable to provide clean-energy solutions for a diversified variety of applications.

Walker said the new power station features a locking stow-pin mechanism in the rotor to prevent rotation when in transit. The rotor assembly also includes a mechanical brake apparatus on the pedestal (in addition to the electrical brake on the controller front panel). The modified utility trailer also has a removable wind shield (with logo) and a protective sleeve fitting over the rotor wings that minimizes apparent wind effects on the turbine while traveling. A retractable pivoting canopy top and framed side coverings provide storage of the station when not in use.

GRTC said an initial wind test demonstrated the new prototype exhibits the same features as its smaller counterparts and begins to charge the 48-volt battery bank in a light 9-mph breeze. Likewise, this newest golden



GRTC's previous smaller prototype success prompted the development of a larger device that could be trailer-mounted and transported to remote areas as a temporary or prolonged power station. (Courtesy: GRTC)

spiral wind turbine is quiet and graceful to behold in motion.

MORE INFO www.goldenratio-turbine-concepts.com

MANUFACTURING

Auburn Bearing & Manufacturing acquires Aurotek TSB

As of February 1, 2021, Auburn Bearing & Manufacturing Inc., an American-based designer and manufacturer of thrust bearings, custom bearings, and precision components, recently announced that it has acquired the assets of Aurotek TSB, Inc.

Aurotek TSB, Inc. specialized in

the production of precision thin section bearings for a broad array of industries. These bearings are used in a variety of applications.

Peter Schroth, president of Auburn Bearing & Manufacturing, notes this acquisition aligns with the company's strategy to expand its product offerings to include American-made precision radial bearings, along with its current thrust ball and roller bearings, in low- to mid- volume production runs and with reasonable lead times.

Aurotek TSB was founded by Dr. Don Cancelmo, who spent his entire career working in the thin section bearing industry. Auburn Bearing & Manufacturing had been a supplier of rings and bearing components to the company since 2011 and is happy to move forward in adding this to its trusted line of bearing products.

Previously located in Herkimer New York, the operations and assets of Aurotek TSB will be moved to Macedon, New York, where the business will continue to operate within the Auburn Bearing & Manufacturing facility at 4 State Route 350, Macedon, New York 14502.

Founded in 1989, Auburn Bearing & Manufacturing, Inc. is one of the oldest continuously operating thrust ball bearing manufacturers in the U.S., and is known for its exclusive line of "V" groove thrust bearings, which are designed to reduce rolling friction. Today, ABM specializes in manufacturing custom ball and roller thrust bearings in low- to mid- volume, as well as in custom manufacturing of precision machined components. ✎

MORE INFO auburnbearing.com

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A large white wind turbine stands in a field of tall, dry grass. In the background, there are rolling hills and mountains under a cloudy sky. Another wind turbine is partially visible on the right side of the image.

CROSSWINDS

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OF WIND



U.K.-based wind developer Windcluster looks to extend the life of its wind turbines reaching the end of their expected service.

As one of the original pioneers of wind energy in the U.K. back in the late 1980s, Windcluster is now among the first to explore the possibilities of wind-turbine life extension.

The current Vestas V52 turbines were installed at its Haverigg site, Cumbria, in 2005 and were originally designed for a 20-year lifespan. However, due to operating under relatively low stress conditions at the site and the provision of a good maintenance regime, the turbines are still in excellent condition, and the directors have successfully gained the consent required to extend the life of the turbines and keep the site operational for a further 15 years.

The landowners readily agreed to extend the existing lease, and the required planning consent was granted by Copeland Borough Council after it was unanimously approved by its members.

“Back in 1988, when I founded Windcluster, people thought I was mad,” said Colin Palmer, founder and managing director of Windcluster. “Fossil fuels and nuclear power were their vision of the future, but they were wrong. Today, Windcluster is part of a multi-billion-pound global industry that is leading the charge to net zero.

“Thirty-three years ago, Windcluster was just an idea, and wind energy was widely dismissed as a passing fad. Hard to believe now, but it was a huge struggle to raise money for the company when we built our first wind turbines in 1992. Undeterred, I managed to raise the money and support we needed to build our first project on a windy airfield in Cumbria, one of the first commercial windfarms in the U.K.”

REPOWERED IN 2004

In 2004, Windcluster repowered the original turbines, and now those replacements are approaching the end of their original planned design life, which makes this the right time for Palmer and the Windcluster team to chart a new course for the future and become pioneers of wind-turbine life extension.

“Our turbines are in very good condition and were over-designed for the site conditions, so we are confident that they will run for long after their original life expectancy,” Palmer said. “Our challenge now is to work out for how long and what we need to do to keep them performing at their best. If all goes well, they could still be turning in 2040, more than 50 years after Windcluster was originally founded.”

There are still four years until the turbines reach the end of their original life in 2025, ensuring there is ample time to carefully plan the management of the life extension. The first step of which is to commission an engineer-

Windcluster's first project, Haverigg I, is located on the disused Haverigg Airfield in Cumbria. (Courtesy: Windcluster)

▼ Our turbines are in very good condition and were over-designed for the site conditions ... If all goes well, they could still be turning in 2040. ▼



The Haverigg I turbines were repowered in 2005 to have an output of 3.4 MW, an asset that Windcluster continues to own and operate. (Courtesy: Windcluster)

ing study of the remaining life, from which components identified for replacement or refurbishment can be considered. At the same time, a condition monitoring system will be installed to determine the ongoing condition of the turbines components. A baseline dataset will also be established from which future performance of key components

can be closely monitored, and a preventative maintenance strategy developed.

ABOUT WINDCLUSTER

Windcluster Ltd was founded in 1988 as one of the pioneers of wind-energy development in the U.K. Palmer, the founder

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Haverigg 1 was commissioned in 1992. It was one of the first commercial wind projects in the U.K. (Courtesy: Windcluster)

of the company, was inspired by developments in Denmark, where small groups of turbines are thoughtfully integrated into the landscape.

Windcluster's first project, Haverigg I, located on the disused Haverigg Airfield in Cumbria, was commissioned in 1992. It was one of the first commercial wind projects in the U.K. The Haverigg I turbines were repowered in 2005 to have an output of 3.4 MW, an asset that Windcluster continues to own and operate. Windcluster has recently secured the necessary consents to extend the life of the turbines and aims to keep them in operation until 2040.

WINDCLUSTER TURBINES

The Vestas V52 turbines at the Windcluster site are classified as IEC Class 1A turbines. This means they were designed to withstand an annual average windspeed of 10m/s and turbulent wind conditions (18 percent turbulence rate).

The site at Haverigg has an annual mean windspeed of about 8.2m/s and a turbulence intensity of 12 percent, considered to be "exceptionally low" by Garrad Hassan, the authors of Windcluster's original wind-speed measurement report. The reason for this is that the site is very exposed to winds from the sea, which are much smoother than those from the land.

STRUCTURAL FATIGUE

All engineering structures are designed to resist a combination of extreme loads and long-term cyclical loading. For wind turbines, the long-term cyclical loading cases tend to be the main design drivers.

This is because of a phenomenon known as structural fatigue. When a component is subjected to repeated load, even at levels much below its extreme failure load level, it will eventually fail. This is structural fatigue, and different materials have different fatigue characteristics.

In general, most engineering materials (and certainly the main materials in wind turbines) follow a power law relationship between the applied stress and the number of cycles. This means that even a relatively small difference in stress levels can result in large differences in the number of cycles that a structure can tolerate before failure.

Because the severity of the cyclical loading is strongly dependent upon the turbulence of the wind regime, Windcluster expects that its turbines still have substantial reserves against fatigue failure.

ONE CAREFUL OWNER

In addition to operating in conditions that are relatively benign when compared to the design specification, Windcluster's turbines have been well maintained. The company has had the comprehensive Vestas AOM4000 service contract throughout their lifetime and also the site has been managed by WPO. ✂

MORE INFO

www.windcluster.co.uk

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