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USING LIDAR TO REDUCE UNCERTAINTY

Lidar is reducing uncertainties and meeting many previously unmet needs for offshore developers

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Setting our sights on 2021

There are a lot of exciting changes going on in the renewables sector, and it's starting with AWEA, itself.

As of January 1, the American Wind Energy Association is the American Clean Power Association (ACP).

Heather Zichal was named the new CEO of the organization in December.

American Clean Power will represent more than 800 member companies from across the renewable energy sector in its first year. The group will reflect the diversity and scale of the modern renewable energy marketplace. ACP will work in close collaboration with other clean-energy trade organizations and advocacy groups.

You'll still see a few AWEA nods in our January issue, but we will be transitioning with ACP, as well as bringing you more news about this exciting change in the coming months.

Making those turbines stand tall are simple bolts and the torquing that keeps them in place. In this issue, the experts at ITH share their insights on its Maintenance-Free-Bolting concept for bolts up to M80

(3 1/8"). It's a method the company boasts will reduce maintenance costs significantly.

Wind measurement is also extremely important when it comes to making sure a turbine will perform optimally.

More frequently, companies have turned to Lidar technology to perform this necessary function, particularly in the offshore sector.

With offshore wind development accelerating around the world, Elvira Aliverdieva looks at how Lidar is reducing uncertainties and meeting many previously unmet needs for offshore developers and operators throughout each stage of a project.

But the wealth of wind information doesn't stop there. In Crosswinds, I'm excited to share with you a really cool article about a ship concept that uses wind to power it. I know what you're thinking: Duh, that's called a sailboat. But this goes far beyond that concept. Check out this fascinating article to find out how.

I hope you enjoy those articles and much more as we enter the new year and continue to share the good news and fascinating stories of the wind industry. The good news just keeps getting better for this renewable energy source.

Take stock in the fact that we made it through 2020, so join me and my team as we look to make 2021 even better. It shouldn't be too hard, right?

Happy New Year, and, as always, thanks for reading!



Kenneth Carter, editor

editor@windssystemsmag.com
(800) 366-2185, ext. 204

David C. Cooper
Publisher

EDITORIAL

Kenneth Carter
Editor

Jennifer Jacobson
Associate Editor

Joe Crowe
Contributing Editor

SALES

David Gomez
National Sales Manager

CIRCULATION

Teresa Cooper
Manager

Jamie Willett
Assistant

DESIGN

Rick Frennea
Creative Director

Michele Hall
Graphic Designer

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Published by Media Solutions, Inc.
P.O. Box 1987 • Pelham, AL 35124
(800) 366-2185 • (205) 380-1580 fax
info@msimktg.com

David C. Cooper
President

Teresa Cooper
Operations Director

Looking to catalyze nearly 1 million U.S. clean-energy jobs

From AWEA

Clean energy resources – wind, solar, energy storage, hydropower, and other renewables – represent a once-in-a-generation opportunity to drive U.S. economic recovery and add hundreds of thousands of family-supporting jobs.

According to a new, first-of-its-kind study recently released by global natural resources research consultancy Wood Mackenzie and the American Clean Power Association (ACP), reaching a majority renewables grid will deploy more than \$1 trillion in capital investment into the American economy over the next decade, while supporting 980,000 direct jobs, stabilizing wholesale power prices, and reducing U.S. carbon emissions by more than 60 percent.

Targeted administrative actions and Legislative policies are essential for the U.S. to achieve these benefits within the next 10 years.

Earlier this year, the American wind, solar, hydro-power, and energy storage industries united around a joint vision to generate over half of the country's electricity within 10 years. Pan-renewable industry leaders agreed to actively collaborate to achieve this target. Today's analysis from Wood Mackenzie details how renewable energy industries can collectively move towards building a more resilient, efficient, sustainable, and affordable American grid.

A recently released Clean Energy Road Map proposed by the American Wind Energy Association, which merged into the American Clean Power Association in January 2021, lays out how the U.S. federal government can rapidly accelerate this economic growth and renewable energy deployment through executive and legislative action starting in 2021. As Wood Mackenzie's analysis makes clear, transmission infrastructure expansion and improvements are critical to enabling this transition to a cleaner American electric grid.



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



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DIRECTION

THE FUTURE OF WIND

Vineyard Wind 1 will be using GE Renewable Energy's industry-leading Haliade-X wind turbine generators, the most powerful in operation to date. (Courtesy: GE)

Vineyard Wind offshore project selects GE Renewable Energy to supply turbines

Vineyard Wind, a joint venture between Avangrid Renewables and Copenhagen Infrastructure Partners, recently announced that the company has selected GE as its preferred supplier of wind turbine generators for its Vineyard Wind 1 project, the first utility-scale offshore wind installation in the United States.

“The selection of GE as our preferred turbine supplier means that a historic American company will play a vital role in the development of the first commercial scale offshore wind power in the U.S.,” said Vineyard Wind CEO Lars T. Pedersen. “This is a huge moment not only for the future of our project, but also for the future of an industry that is poised for exponential growth in the coming decades.”

Vineyard Wind 1 will be using GE Renewable Energy’s industry-leading Haliade-X wind turbine generators, the most powerful in operation to date.

With this selection, GE Renewable Energy is poised to play a pivotal role in the development of offshore wind power in the U.S., which will be a major source of investments and job creation up and down the supply chain in communities across the region.

“GE Renewable Energy is proud to partner with Vineyard Wind for the first major offshore wind project in the U.S.,” said John Lavelle, president and CEO, Offshore Wind at GE Renewable Energy. “To be selected as the preferred supplier is an important sign of confidence for our proven technology and for all our employees around the world. We look forward to making this important contribution to the growth of offshore wind in the U.S.”

As a part of reaching this important milestone, Vineyard Wind has decided to temporarily withdraw its Construction and Operations Plan (COP) from further review by the Bureau of Ocean Energy Management (BOEM) to allow the project team to conduct a final

technical review associated with the inclusion of the Haliade-X into the final project design.

“While the decision to pause the ongoing process was difficult, taking this step now avoids potentially more federal delays and we are convinced it will provide the shortest overall timeline for delivering the project as planned,” Pedersen said. “We intend to restart the BOEM process from where we left off as soon as we complete the final review.”

The company expects its review to take several weeks, after which Vineyard Wind will resume the federal permitting process with BOEM. With buffer built into the project schedule, Vineyard Wind still expects to reach financial close in the second half of 2021 and to begin delivering clean energy to Massachusetts in 2023.

Vineyard Wind 1 is an 800-MW project 15 miles off the coast of Martha’s Vineyard and is slated to become the first large-scale offshore wind farm in the United States. The project will generate cost-competitive electricity for more than 400,000 homes and businesses in the Commonwealth of Massachusetts and is expected to reduce carbon emissions by more than 1.6 million tons per year.

MORE INFO www.vineyardwind.com

Timken launches \$75+ million in wind, solar investments

The Timken Company, a world leader in engineered bearings and power transmission products, recently announced more than \$75 million in capital investments through early 2022 to increase the company’s renewable energy capabilities across its global footprint.

“This has been a breakout year for us in renewable energy markets,” said Richard G. Kyle, Timken president

and chief executive officer. “Through both innovation and acquisitions over the last several years, we’ve become a leading supplier and technology partner in wind and solar energy, and it’s resulting in record sales and a robust pipeline of opportunities. This latest round of investments represents our confidence in the future growth of our wind and solar business as the world continues to transition to renewable energy sources.”

To serve Timken’s global renewable energy customers, the company has developed an extensive network of engineering and innovation centers and manufacturing facilities throughout the U.S., Europe, and Asia. Timken will use the announced \$75 million investment to:

- Expand its state-of-the-art and LEED-certified manufacturing facility in Xiangtan, China, where it makes engineered bearings for wind turbines.

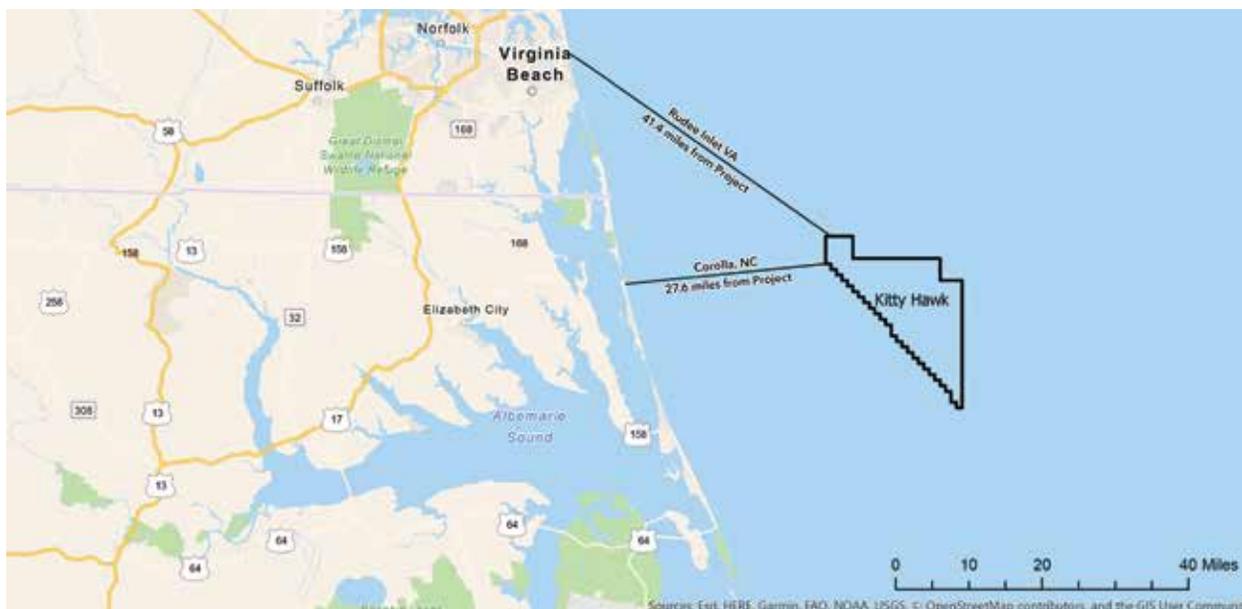
- Continue to scale-up its production capacity at sites in Wuxi, China, and Ploiesti, Romania, where Timken manufactures engineered bearings for wind turbines.

- Consolidate multiple sites into a new, larger campus in Jiangyin, China, to increase production capacity, broaden the product range and improve productivity for precision drives used in the solar energy market.

- All of the above investments will include advanced automation and manufacturing technologies.

Timken’s wind energy product portfolio includes engineered bearings, lubrication systems, couplings, and more. Timken has been active in the wind market for more than 10 years and is now a critical design and manufacturing partner to many of the world’s largest turbine and drive manufacturers.

Timken’s 2018 acquisition of Cone Drive launched the company’s leading position in the solar energy sector. Timken develops and manufactures precision motion control products



Kitty Hawk Offshore is an offshore wind project proposed more than 27 miles from the Outer Banks. (Courtesy: Kitty Hawk Offshore)

that provide solar-tracking system positioning for both photovoltaic (PV) and concentrated solar power (CSP) applications.

“Timken is known throughout the world for our ability to solve our customers’ most difficult friction-management and power-transmission challenges, and that includes deploying our advanced engineering and manufacturing technologies to help produce the world’s most efficient and reliable wind turbines and solar-energy systems,” Kyle said. “By continuing to invest and advance our technology, Timken will help the renewable energy industry improve efficiency, reduce cost and promote the growth of solar- and wind-energy sources.”

MORE INFO www.timken.com

Avangrid submits construction plan for Kitty Hawk project

Avangrid Renewables, a subsidiary of AVANGRID, Inc., a leading developer of onshore and offshore wind in the U.S., recently submitted a construction and operations plan (COP) to the federal Bureau of Ocean Energy Management

(BOEM) for the first phase of the company’s wholly owned Kitty Hawk Offshore Wind project.

The COP also includes the findings from an economic impact study (EIS), conducted by the Public Strategy Group, which anticipates substantial economic and employment benefits to result from the construction of Kitty Hawk Offshore Wind’s multiple phases between 2021 and 2030.

“We’re proud to be the first to submit a federal permit for a commercial scale offshore wind project in Virginia and the Carolinas,” said Bill White, Avangrid Renewables’ head of U.S. offshore wind. “Kitty Hawk Offshore Wind will deliver clean energy to customers in the region and significant economic benefits and quality jobs for decades to come.”

The first phase of the project, anticipated to begin construction as soon as 2024, will have the capacity to generate approximately 800 MW of electricity.

When all phases are complete, Kitty Hawk Offshore Wind is expected to have a total generation capacity of up to 2,500 MW, or enough to power 700,000 homes — approximately four times the number of households in Virginia Beach

— with clean energy.

“The offshore wind industry presents tremendous opportunity to the Hampton Roads region,” said Doug Smith, president and CEO of the Hampton Roads Alliance. “I look forward to working with Avangrid Renewables as they develop the Kitty Hawk Offshore Wind project and deliver substantial economic benefits to the Hampton Roads region.”

The EIS found that the project will drive significant economic activity and employment opportunity in the region. Kitty Hawk Offshore Wind is expected to generate \$2 billion in economic impact between 2021 and 2030 and is expected to create nearly 800 jobs in Virginia and North Carolina, with nearly 600 of those in the Hampton Roads region which includes southeastern Virginia and northeastern North Carolina.

MORE INFO www.kittyhawkoffshore.com

Siemens Gamesa appoints Marc Becker as CEO of Offshore

Siemens Gamesa Renewable Energy recently announced that Marc Becker

is to return to the company as CEO of its industry-leading offshore business.

Becker served as managing director for Germany and head of Offshore Sales and Projects at Siemens Gamesa before leaving the company in early 2020. In the latter role, and previously as COO of Siemens Wind Power, Becker played a key role in building the company's strong leadership position in the rapidly growing offshore segment.

Becker, who is to be the permanent replacement for Andreas Nauen, who was promoted to CEO of the company in June, will be based in Hamburg and start his new role February 1. Pierre Bauer will continue as interim CEO in the meantime.

"I am delighted to bring Marc back to the company to lead offshore," Nauen said. "He has an outstanding track record in offshore wind energy and has the experience, expertise, and industry network to lead our future growth in this critical area. With the addition of Marc, we will complete a strong and revitalized team to lead the turnaround that will deliver long-term sustainable growth and profitability to Siemens Gamesa."

"Siemens Gamesa is the undisputed leader in offshore wind, and I'm looking forward to rejoining the company and working to extend that leader-

ship," Becker said. "There is huge potential for offshore wind to lead the fightback against climate change, and with the talented team at Siemens Gamesa as well as the industry's best technology, we are well positioned to play a leading role."

Becker will join a senior management team that was overhauled in the second half of 2020. Lars Bondo Krogsgaard, former CEO of Nordex

Acciona and co-CEO of MHI Vestas, joined as CEO of onshore earlier in November. Juan Gutierrez took over as CEO of Service in August.

Beatriz Puente joined as Chief Financial Officer on December 1 from NH Hotels, where she has served as Executive Managing Director Finance & Administration since 2015. ↘

MORE INFO www.siemensgamesa.com



Marc Becker (Courtesy: Siemens Gamesa)



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USING LIDAR TO REDUCE UNCERTAINTY IN OFFSHORE WIND DEVELOPMENT

There is a Lidar technology to support every stage of an offshore project. (Courtesy: Vaisala)





With offshore wind development accelerating globally, Lidar is reducing uncertainties and meeting many previously unmet needs for offshore developers and operators throughout each stage of a project.

By ELVIRA ALIVERDIEVA

Offshore wind development is gaining momentum around the globe. Expected to constitute more than 20 percent of total wind energy installations by 2025, offshore wind is growing in both near-shore environments and in deeper waters farther from the coast.

The United States, supported by a combination of federal incentives and state-level targets, is witnessing strong growth in offshore wind, with the goal of 9 GW generated by 2026 and planned commitments to build projects delivering 26 GW along the east coast by 2035. But as offshore development increases, so do concerns with uncertainty. Ensuring accurate data is delivered during wind resource assessment is essential for developers looking for bankability during the development stages and for wind monitoring and power performance testing during operations.

OFFSHORE WIND: NEW OPPORTUNITIES AND NEEDS

While offshore wind farms are full of potential, they also bring a new set of challenges. Offshore wind projects are bigger; turbines are growing larger, and the cost of offshore projects is greater compared to onshore. From the ability to accurately assess wind characteristics for larger areas and taller turbines to obtaining precise wind data at long ranges from the shoreline, offshore wind project challenges are compounded by the fact that meteorological masts are often either impossible or prohibitively expensive to deploy and maintain.

Met masts usually cannot measure up to the full height of modern turbines without mathematical extrapolation, which potentially introduces error. With offshore wind moving farther into deeper waters and farms maximizing the value of each foundation by employing the largest possible turbines, met masts simply cannot aggregate accurate wind data and stay within a cost-effective budget.

Lidar is both simpler to deploy and repurpose throughout the life cycle of an offshore project and is able to measure the full wind profile of even the largest offshore tur-



Vertical profiling and scanning Lidars can be mounted on existing offshore platforms or placed onshore at the coastline. (Courtesy: Vaisala)

bines, including those with floating foundations. Not only does this mean that Lidar reduces uncertainty by providing directly measured data where met masts would rely on extrapolation, but it also guarantees that Lidar will continue to accommodate aggressive turbine growth in the coming years.

As offshore wind accelerates, developers and operators are increasingly looking at offshore Lidar technology to reduce costs, speed up their projects, and maximize wind-turbine performance and profitability. But what technologies should they use to fit their needs and reduce uncertainty?

LIDAR FOR EACH STAGE OF AN OFFSHORE PROJECT

The good news is there is a Lidar technology to support every stage of an offshore project: from wind resource assessment, pre-construction, and contractual power curve

testing to permanent wind monitoring, research and development, and turbine testing and control.

WIND-RESOURCE ASSESSMENT

Wind-resource assessments are useful only if their uncertainty is well defined. If the wind availability and characteristics cannot be proven to a high degree of certainty, it's not possible to construct a sound financial model for a wind-project investment.

Mountable on existing offshore platforms or placed onshore at the coastline, vertical profiling and scanning Lidars decrease uncertainty by providing both the spatial resolution to analyze bigger areas (scanning) and direct wind assessment to reduce vertical uncertainty (vertical profiling), improving project bankability. With a range of nearly 20 kilometers from the shoreline, advanced scanning Lidar technology allows for full, 3D spatial mapping of the



When used for permanent wind monitoring, fixed vertical profiling and nacelle-mounted Lidars can replace met masts and monitor performance and losses when a turbine is stopped or the farm is off the grid. (Courtesy: Vaisala)



Lidar can reduce uncertainties and meet many previously unmet needs for offshore developers and operators. (Courtesy: Vaisala)

wind field and can provide ideal offshore site wind data even from the shoreline, where it is much easier and more cost-effective to operate and maintain. In fact, a near-offshore scanning Lidar or a vertical profiling Lidar placed on a fixed offshore platform is often the simplest solution with the lowest upfront costs.

A crucial tool where there are no available fixed platforms, lighthouses, or offshore stations, floating Lidar technology can be deployed for wind-resource assessment nearly anywhere. Even better, these technologies can be mixed and matched. For example, a buoy-mounted vertical profiling Lidar can be integrated into a floating Lidar system or placed on a platform at the center of a proposed project to reduce vertical uncertainty, while one or several scanning Lidar units provides 3D wind awareness from the shore.

WIND OPERATIONS AND POWER PERFORMANCE TESTING (PPT)

When used for permanent wind monitoring, fixed vertical profiling and nacelle-mounted Lidars can replace met masts and monitor performance and losses when a turbine is stopped or the farm is off the grid.

Used to verify performance or validate repairs and upgrades, operational PPT is crucial. Quick and affordable to deploy, nacelle-mounted Lidar technologies provide reliable data immediately, making them well suited for troubleshooting and identifying underperformance. Plus, these Lidars measure horizontal wind hundreds of meters in front of the turbine to simplify PPT and ensure even the largest offshore turbines are performing at maximum capacity.

RESEARCH, DEVELOPMENT, AND CONSTRUCTION

Wind Lidar is frequently being used for promising research and development (R&D) purposes, such as wake loss and blockage effect studies as well as short-term forecasting. In wake loss studies, scanning Lidar technology is improving energy production certainty by measuring wake effects away from the turbine, ultimately improving performance and financial outcomes. In research applications, real-time



Floating Lidar technology can be deployed for wind-resource assessment nearly anywhere. (Courtesy: Vaisala @ Jacques Vapillon - AKROCEAN GEPS)

Lidar data decreases uncertainties compared to statistical models. Fixed vertical profiling Lidars are also commonly used during craning and mounting operations because they help ensure accurate turbine placement and installation. Nacelle-mounted Lidars also support other research areas such as wind-farm control.

With offshore wind development accelerating globally, Lidar is reducing uncertainties and meeting many previously unmet needs for offshore developers and operators throughout each stage of an offshore project. Innovative Lidar technologies — whether scanning, ground-based, floating, or nacelle-mounted — exhibit that, with the right tools, offshore wind farms are both feasible and profitable. ✌

ABOUT THE AUTHOR

Elvira Aliverdieva is a product specialist for Leosphere, a Vaisala company. She participates in the evolution of the company's onshore and offshore wind product strategy — including its Lidar-based WindCube® suite of products — with a primary focus on the booming offshore market.

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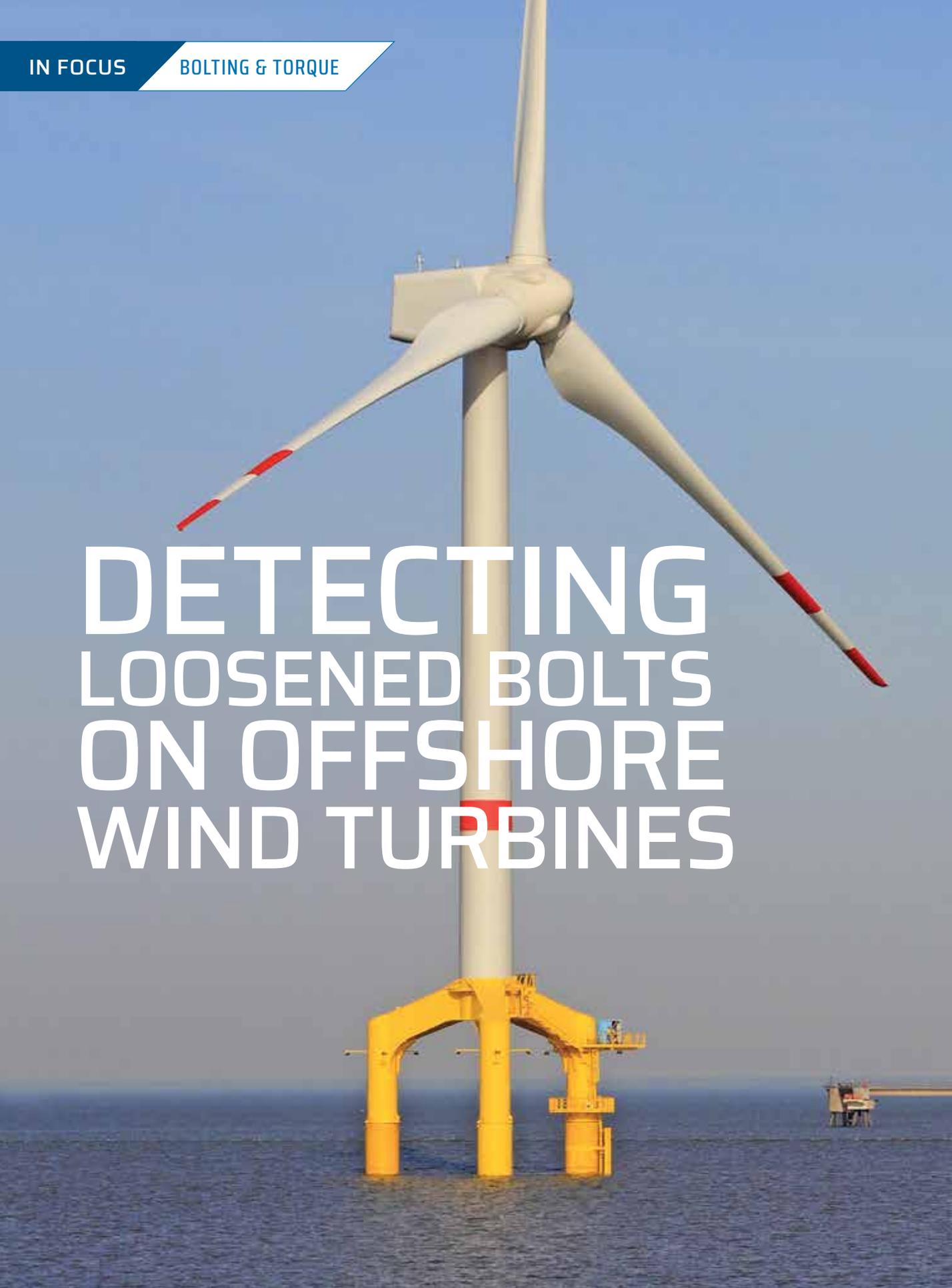
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BOLTING & TORQUE

DETECTING LOOSENED BOLTS ON OFFSHORE WIND TURBINES

A large offshore wind turbine stands in the middle of the ocean under a clear blue sky. The turbine has three white blades with red tips and a yellow support structure. The text 'DETECTING LOOSENED BOLTS ON OFFSHORE WIND TURBINES' is overlaid in large white letters.

In the normal operation of an offshore wind turbine, bolts can loosen due to long-term operation and exposure to vibration; however, a proposed device could help detect loosened bolts before extensive damage can occur.

By WANG FEI and QU JUN

For the problem of loosened bolts in the long-term operation of an offshore wind turbine, we proposed a device to detect loosened bolts. The device included a vibration sensor, a signal receiver and transmitter, a CCD sensor, a data analyzer, power supply, a communication line, and a power supply line. The combination of a data analyzer and CCD sensor was used to analyze whether the prefabricated symbols on the bolts change, so as to judge whether the bolts are loose. The whole system (except the vibration sensor) would be in a standby and dormant state at normal times, which is simpler and more reliable under harsh ocean conditions.

1 INTRODUCTION

The operating environment of an offshore wind turbine is worse than on land. In the normal operation of an offshore wind turbine, the bolts of the connecting parts are easy to loosen because of the long-term operation and the resultant force of various vibrations. When the bolts of main working parts are loose, it can cause severe shaking faults. The loosened fixing bolts of the typical generator base can cause the wind turbine to vibrate violently. If the affected parts are not found in time, the steel wire rope cable can be pulled out, and the wind turbine could fall and be damaged [1-2].

According to the existing literature [3-5], the main causes of loosened bolts are:

- ▮ A deviation in the installation of the main operating parts of the fan, which leads to a large vibration during the operation of the fan and the gradual loosening of the nuts of the bolts.

- ▮ The bolts are not fastened in place, which leads to the gradual loosening of the nuts under the vibration.

- ▮ The material characteristics of the bolts are not qualified, and the diameter of the bolts is gradually narrowed under the vibration, which leads to the gradual loosening of the nuts.

At present, the main preventative method to ensure bolts are properly tightened is regular inspection by the operation and maintenance personnel. Because the working environment of the wind turbine is at sea, compared with the onshore wind turbine, the transportation and labor costs are significantly increased. With a proposed bolt loosening detection device for the offshore wind turbine, the combination of a data analyzer and CCD sensor would be used to analyze whether the prefabricated symbols on the bolts change, so as to determine whether the bolts are loose. Compared with other methods of detecting bolt looseness, the strategy of this method is simple. The entire system (with the exception of the vibration sensor) would be in standby

mode during normal operation, and the device is simpler and more reliable under harsh ocean conditions.

2 STRESS ANALYSIS OF TYPICAL BOLTS

In connecting the bolt, a connector is clamped by a large tightening pretension in the bolt rod, which produces a large friction force to improve the integrity and rigidity of the connector. The typical high-strength bolt used for a wind-turbine tower was designed for shear resistance according to the friction type connection.

The stress diagram of a typical wind turbine tower flange bolt is shown in Figure 1. Due to the existence of tightening torque T , there is a preload F_0 between the bolt and wind-turbine tower flange. The tightening torque T is equal to the sum of the friction resistance moment T_1 between the screw pairs and the friction resistance moment T_2 between the ring end face of the nut and the support surface of wind turbine tower flange. The friction resistance moment T_3 between the annular end face of the bolt head and the support surface of the fan tower flange produces the reverse moment, which is equal to T [6].

$$\begin{aligned} T &= T_1 + T_2 \\ T_2 &= T_3 \end{aligned}$$

The expression of friction moment between screw pairs is

$$T_1 = F_0 \frac{d_2}{2} \tan(\psi + \varphi_v)$$

The symbol d_2 is the pitch diameter of the thread. The symbol ψ is the thread-rising angle. The symbol φ_v is the equivalent friction angle of the screw pair.

Also, the friction moment between the nut and the flange surface of the wind turbine tower is

$$T_2 = \frac{1}{3} \mu_c F_0 \frac{D_0^3 - d_0^3}{D_0^2 - d_0^2}$$

The symbol μ_c is the friction coefficient between the nut and the support surface. The symbol D_0 is the outer diameter of the bolt ring support surface. The symbol d_0 is the bolt hole diameter.

Substituting Equation 3 and Equation 4 into Equation 1, we get:

$$T = \frac{1}{2} F_0 \left[d_2 \tan(\psi + \varphi_v) + \frac{2}{3} \mu_c \frac{D_0^3 - d_0^3}{D_0^2 - d_0^2} \right]$$

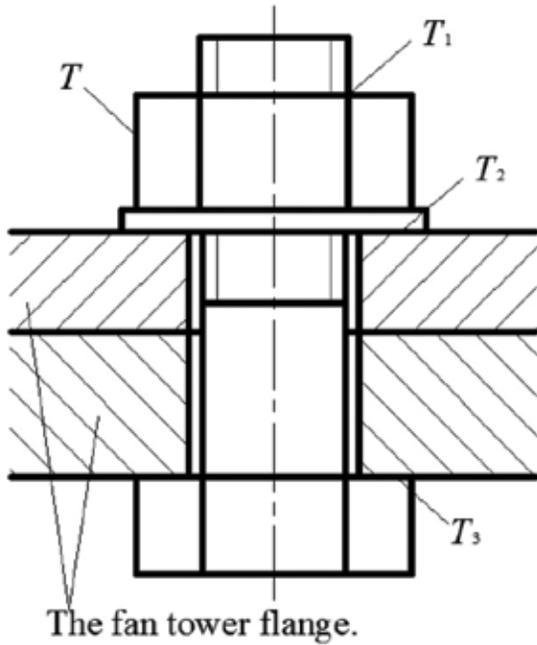


Figure 1: The schematic stress analysis diagram of typical bolts.



Figure 3: A typical piezoelectric acceleration sensor.

The methods of vibration measurement in engineering include the mechanical method, optical method, and electrical method. Among them, the most widely used electrical measurement method was to convert the

mechanical vibration into electricity and then measure and convert the electricity to make it a signal output.

For a certain type of bolt, the parameter in the bracket of Equation 5 is the fixed value, and the tightening torque T is directly proportional to the pre-tightening force F . Due to this, the pre-tightening force F of the bolt decreases, which further reduces the tightening torque T of the bolt, and finally the bolt loosens.

3 THE COMPONENT OF BOLT LOOSE JUDGING DEVICE

As shown in Figure 2, the loosened bolt judging device for an offshore wind turbine includes a vibration sensor, signal receiver and transmitter, CCD sensor, data analyzer, power supply, the communication line, and the power supply line.

The data analyzer was connected with the vibration sensor, signal receiver and transmitter, and CCD sensor respectively through the communication line. The power

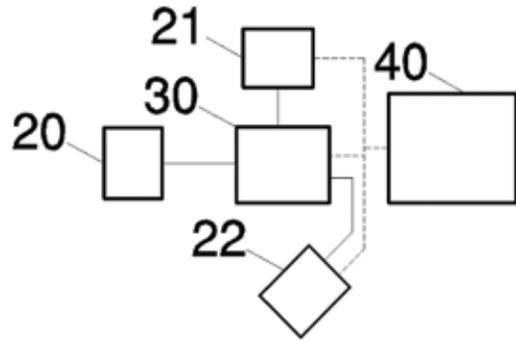


Figure 2: Component sketch of loosened bolt detection device. 20: Vibration sensor, 21: Signal receiver and transmitter, 22: CCD sensor, 30: Data analyzer, 40: Control device, 40: Power supply.

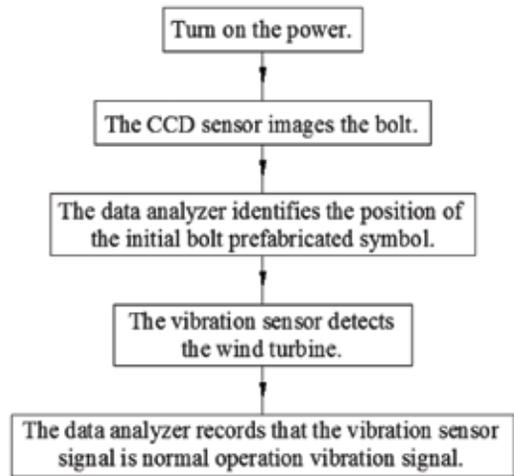


Figure 4: Flow chart of preliminary commissioning preparation.

supply was connected with the signal receiver and transmitter, data analyzer, and CCD sensor respectively through the power supply line.

According to their working principles, the specific vibration measuring sensors can be divided into piezoelectric, piezoresistive, capacitive, inductive, and photoelectric types. As shown in Figure 3, the piezoelectric acceleration sensor was the most commonly used vibration measurement sensor because of its wide measuring frequency range, large measuring range, small volume, light weight, small impact on the measured parts, and convenient installation and use. We chose the piezoelectric acceleration sensor here.

4 OPERATION METHOD OF THE DEVICE

4.1 Preliminary commissioning preparation

As shown in Figure 4, the power supply was turned on first, followed by the vibration sensor, signal receiver and transmitter, CCD sensor, and data analyzer. The CCD sensor images the bolt, which transmits the initial state image of

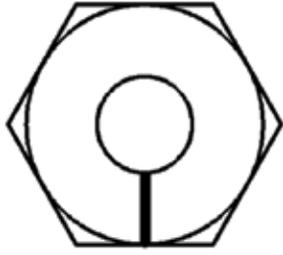


Figure 5: The position of the initial bolt prefabricated symbol in the initial state image of the bolt.

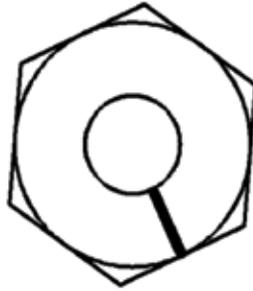


Figure 6: The bolt prefabricated symbol position A in bolt status imaging.

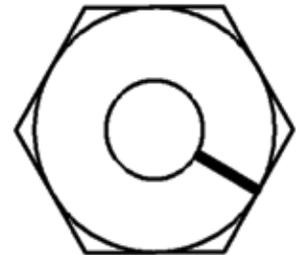


Figure 7: The bolt prefabricated symbol position B in bolt status imaging.

the bolt to the data analyzer through the communication line. As shown in Figure 5, the data analyzer identified the position of the initial bolt prefabricated symbol in the initial state image of the bolt, and the CCD sensor entered the standby sleep state.

During the normal operation of the wind turbine, the vibration sensor detected the wind turbine in real time and transmits the vibration signal to the data analyzer through the communication line. The data analyzer recorded that the vibration sensor signal is a normal operation vibration signal at this time.

4.2 Daily maintenance and inspection state

At the end of the routine maintenance inspection cycle, the background operator sent the routine maintenance inspection signal to the signal receiver and transmitter. The signal receiver and transmitter will transmit the daily maintenance and inspection signal to the data analyzer through the communication line, and then the data analyzer will activate the CCD sensor to be in the working state through the communication line. The CCD sensor will image the bolt state through the communication line to the data analyzer, and the CCD sensor will enter the standby sleep state.

As shown in Figure 6, the data analyzer identified the bolt prefabricated symbol position A during bolt status imaging, which was different from the initial bolt prefabricated symbol position. The data analyzer connected the signal receiver and transmitter through the communication line, and the signal receiver and transmitter transmitted the signal of the loosened wind-turbine bolt. When the data analyzer recognizes that the position of the bolt prefabrication symbol is the same as that of the initial bolt prefabrication symbol, the signal receiver and transmitter will transmit the normal signal of the wind-turbine bolt.

4.3 Severe shaking state of wind turbine

When the wind turbine shakes violently due to loosened bolts, the vibration sensor will transmit the vibration signal B of the wind turbine to the data analyzer through the communication line. The data analyzer compared the vibration signal B of wind-turbine operation with that of a normal operation and concluded that the vibration signal B of the wind-turbine operation is the vibration signal of an abnormal operation.

The data analyzer activated the CCD sensor to be in the working state through the communication line, and the

CCD sensor transmitted the image of the bolt state to the data analyzer through the communication line. The CCD sensor then entered the standby sleep state. As shown in Figure 7, the data analyzer identified the position B of the bolt prefabrication symbol in the image of the bolt status, which was different from the position of the initial bolt prefabrication symbol. The data analyzer connected the signal receiver and transmitter through the communication line, and the signal receiver and transmitter transmitted the signal of a loosened wind-turbine bolt.

CONCLUSIONS

The bolt loose judging device for offshore wind turbine included a vibration sensor, signal receiver and transmitter, CCD sensor, data analyzer, power supply, the communication line, and the power supply line. The device included a daily maintenance and inspection state and a severe shaking state of the wind turbine. The combination of the data analyzer and CCD sensor was used to analyze whether the prefabricated symbols on the bolts change, so as to judge whether the bolts are loose. The entire system (except the vibration sensor) has been in standby mode at normal times, which is simpler and more reliable under the harsh conditions at sea. ✎

ABOUT THE AUTHORS

Wang Fei and Qu Jun are with the College of Energy and Mechanical Engineering, Shanghai University of Electric Power, Shanghai 200090, China. © The Authors, published by EDP Sciences. This is an open access article (doi.org/10.1051/e3s-conf/202019403007) distributed under the terms of the Creative Commons Attribution License 4.0 (creativecommons.org/licenses/by/4.0/). It has been edited to clarify some language and to conform to the style of Wind Systems magazine.

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MAINTENANCE-FREE-BOLTING CONCEPT FOR BOLTS UP TO M80 (3 1/8")

Maintenance-Free-Bolting
concept by ITH Bolting
Technology: IHF bolts, IHF
roundnuts, and digital
monitoring and application
management for ITH Bolt
Tensioning Cylinders.
(Courtesy: ITH)

ITH Bolting Technology combines digital bolting tool procedures, advanced fastener design, and installation know-how to reduce maintenance costs significantly – proven for onshore and offshore wind-turbine installation projects.

By ITH BOLTING TECHNOLOGY

ITH Bolting Technology is a leading global system supplier in bolting technology providing bolting tools, engineering, fasteners and service. Under their brand, IHF Fastener Systems, ITH has developed innovative fastener systems up to M80 (3 1/8”), which are specifically designed to match the technical demands of onshore and offshore wind turbine joints.

The “Maintenance-Free-Bolting” concept includes the technical coordination of ITH bolting tool systems with digital management software, specifically designed IHF fasteners, and advanced installation process know-how. The technical combination leads to repeatable, fast, and precise bolting procedures, which helps to reduce costly maintenance intervals on onshore and, especially, offshore wind turbines significantly.

BOLTING TOOL METHOD AND DIGITAL MANAGEMENT SOFTWARE

ITH bolt tensioning cylinders work according to the hydraulic, torsion-free, and friction-free bolt tensioning method. The method guarantees reproducible pre-tensioning forces within a close tolerance of ±2.0 percent. For this method, ITH has developed a digital application management system, which offers customizable functions such as data-logging and step-by-step user guidance.

Depending on the demand of the customer, the bolting procedure and functions can be modified. All captured data such as applied pressure, applied preloads, angles of rotation of the nut run-down, bolt-ID, and more application data can be sent to a customer cloud.

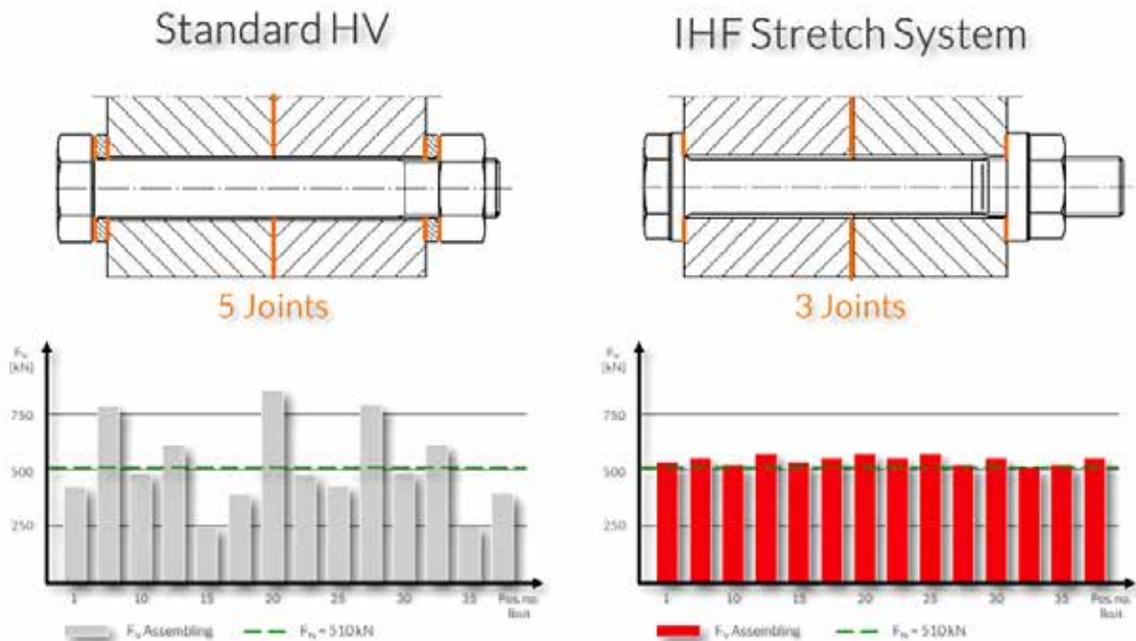
MULTI-CERTIFIED IHF FASTENER DESIGN AND BENEFITS

Bolted joints on steel constructions can be classified according to the HV-standard (HV stands for high-strength) according to DIN EN 14399 and DASt 021. Wind-turbine tower segments are mainly subjected to this standard, which determines that bolts are torqued and fastener sets consist of a bolt, a nut, and two washers. Torqueing is subjected to friction effects, which can affect the implementation of the applied preload forces FM negatively.

Innovative IHF fasteners – head bolts (in general up to M64, 2 1/2”), studs and round nuts (up to M80, 3 1/8”) – are based on an optimized design to meet the technical demands of wind-turbine joints in terms of material, coatings, pre-load distribution, notch categories, and dimensions.

Compared to conventional HV-standard joints, IHF Fasteners offer several advantages:

- Integrated washers: In contrast to an HV-set, the more recent bolt and nut set consists only of two components, the

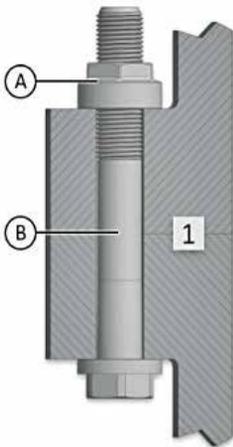


Conventional HV-standard configuration compared to IHF fastener configuration and applied preloads for bolt size M36 (1 3/8”). (Courtesy: ITH)

IHF Fastener set configurations

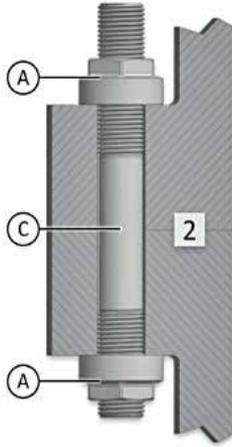
Configuration 1
head bolt
(IHF standard)

- A. 1x IHF Roundnut
- B. 1x IHF Stretchbolt

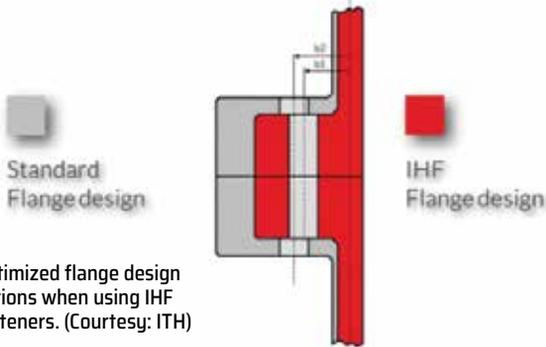


Configuration 2
stud bolt

- A. 2x IHF Roundnut
- C. 1x IHF Studbolt



IHF configuration with IHF roundnuts: No washers required. IHF roundnuts can be used with IHF head bolts, in general, up to M64, 2 1/2" or IHF studs bolts up to M80, 3 1/8". (Courtesy: ITH)



Optimized flange design options when using IHF fasteners. (Courtesy: ITH)



Set of IHF roundnuts and IHF head bolts. (Courtesy: ITH)

▶ ITH hydraulic bolt tensioning cylinders can be equipped with handling systems and automatization components, which enable a semi-automatic nut run-down and an automatic nut alignment. ▶

IHF stretchbolt and roundnut, which simplifies and accelerates the installation process, especially offshore.

▶ Design and optimized load distribution enable higher utilization of the material.

▶ This allows for a use of a) fewer number of IHF fasteners compared to standard fasteners or b) a reduction of the dimensions of the flange.

Due to their proven design, IHF round nuts up to M80 (3 1/8") have received the European Technical Approval (ETA) by the DIBt (German Institute of Construction) to be applied as a substitute for conventional HV-standard fastener configurations.

INSTALLATION KNOW-HOW AND RESULTS

The "Maintenance-Free-Bolting" concept also includes several components that lead to a faster installation process. ITH hydraulic bolt tensioning cylinders can be equipped with handling systems and automatization components, which enable a semi-automatic nut run-down and an automatic nut alignment. Both automatization components are managed by the ITH software. Via an industrial touch-panel PC, users get a visual step-by-step process guidance. Bolt-tightening procedures are often subjected to the risk of possible incorrect operation, which is avoided by the user guide.

This process design not only accelerates installation procedures but also guarantees precise results. Special offshore packaging and the fact that no washers are required also simplifies and accelerates the installation.

WIND TURBINE APPLICATION AND SOLUTIONS

The "Maintenance-Free-Bolting" concept is in use on:

- ▶ Turbine tower bolts.
- ▶ Transition-piece to tower bolts.
- ▶ Monopile-to-transition piece.

Next to the Maintenance-Free-Bolting-Concept, ITH Bolting Technology also provides bolting tools, fasteners, and service for main wind turbine nacelle bolting applications. Comprehensive support in terms of installation supervision, tool maintenance, tool calibration (A2LA-certified up to 60,000 psi), and more is guaranteed by the global ITH network. ↙

ABOUT THE COMPANY

ITH Bolting Technology is a developer, producer, and distributor of hydraulic bolt tensioning tools and torque wrenches for tightening and loosening bolt connections from M 16 (3/8") and up. For more information, go to www.ITH.com.

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Dr. Richard Misiaszek

Corporate Medical Director ▶ Remote Medical International

“We had to learn different ways to adapt our strategies to maintain operational function and stability moving forward, knowing that COVID-19 could impact an operation.”

▶ What is your background in providing care and guidance to remote industrial areas?

I’m a board-certified emergency room physician. I still practice clinically, and I’ve been with Remote Medical International since 2017. My initial job with the company was as the topside physician. I was the physician that our providers in a remote location would call in to discuss a case. I did that for probably two solid years. I still do that occasionally now, and I became really comfortable talking with providers in industrial, construction, offshore locations, and really remote and challenging environments with limited communications, resources, and management options.

We became very good at handling cases without a lot of the backup resources that I would have had working in an emergency department. Having done that for several years, I am pretty comfortable with understanding clinical limitations, as well as operational impact, managing cases in those environments, and deciding when to evacuate somebody. I also have experience in preparing our medical providers to go out and operate in those types of remote environments.

▶ How’s the COVID-19 pandemic forced a change in established safety measures?

I think it’s forced almost everything to change.

There is a significant amount of preparedness that has to happen for somebody to remain operationally stable or for an operation or a project to actually happen. There are quite a number of enhanced measures that have to be put into place to allow that to happen successfully. We witnessed many aspects of normal operations being shut down early during the pandemic and continuing for some time.

We had to learn different ways to adapt our strategies to maintain operational function and stability, knowing how COVID-19 could potentially impact operations. This

took different forms such as enhanced safety measures — whereby a lot of clients would look at their operation and design a protocol or an approach that would mitigate the risk as much as possible.

And that’s really what this became — a risk mitigation effort for a lot of industries. You’d have key stakeholders from the client or from the company, you’d get some medical guidance and input and safety guidance, and you would design a system that would mitigate as much risk as possible. This involved many different things in the beginning. Everybody talked about hand hygiene; they talked about social distancing, and they talked about masking. These are now essential elements of any approach.

And, to the extent that it was operationally possible, efforts were put into place within the industry and on projects to enhance those precautions. These include requiring masking where possible, encouraging and enforcing social distancing, improving hand hygiene, or changing shift scheduling accordingly to minimize the number of people working. It remains critical that people who are essential to a given project are able to function with as much distancing as possible and with as much support as they need to do their job in the safest manner possible.

There are other measures as well. We want to have a project be as successful as possible and minimize the chance that it would be shut down because of a widespread COVID-19 outbreak. We put a significant effort into screening personnel who are going out to work remotely. That takes different forms. For example, if people are traveling on to a site, in general, a version of quarantine is required before they are able to mobilize.

We screen and conduct temperature checks throughout the quarantine period. Do you have any signs or symptoms consistent with COVID-19? And if so, how did you report? Who did you report to? When?



The COVID-19 pandemic became a risk mitigation effort for a lot of industries. (Courtesy: Remote Medical International)

These are typical. But then we also layer in different testing strategies within the screening process. For example, we would incorporate PCR tests at a certain point in time during quarantine or prior to deploying to go offshore or to a remote location in order to further minimize the risk. This carried on to the project site as well, whereby people often may have to screen before they begin work. Additionally, measures were put in place to identify somebody who might be sick at work along with the preparedness protocols that address what to do if someone is sick.

Much of this preparedness stemmed from: We're going to put somebody out there. We've got our enhanced safety measures in place. We're going to screen them. We're going to test them. We're going to educate them as much as possible. But now we have to plan for the possibility that COVID-19 does affect our project site.

The contingency planning had to be in place whereby you identify an individual that could be sick, identify any close contacts to that individual, then isolate those individuals to potentially prevent infecting the entire workforce and shutting down the operation. That's what we try to drive home. It takes a multifaceted approach to maximizing health and safety, while minimizing the risk of COVID-19 shutting down an operation.

▀ Can you speak about how the wind industry has handled the COVID-19 pandemic?

Recently, Remote Medical International acquired SSI, an organization that has a lot of experience working with wind in a number of different settings. From what we've seen, I would say that wind is very similar to a lot of other industries in terms of how they're managing COVID-19.

Wind workers are in a particularly challenging and remote environment just because of the complexity of what it is they're doing. But then you add in these enhanced safety measures where you're trying to make sure that when somebody goes out to work on a project that they're as safe as possible.

So, you get into screening, testing, enhanced preparedness options, and enhanced safety measures as I've mentioned.

In terms of actually managing somebody, you have

to consider the particularly challenging environment involved with wind farms. Then we layer in these added approaches for identifying somebody with possible symptoms onsite and if that could possibly infect a whole bunch of people and shut down the operation. It's mirroring the approaches a lot of different industries – whether it's seabed exploration, oil and gas, pipelines, etc. – they are all taking steps to minimize the impact of COVID-19 affecting their project.

▀ A wind technician's job can be a solitary one, and sometimes they're the only ones out there at any given time. Does that mean they tend to be safer in this situation?

I would say absolutely although they are never working alone and as a minimum work in pairs. COVID-19 is a viral illness. Obviously, that's a very challenging sort of environment to operate in any way. But in environments where there is a greater degree of isolation, the fewer people working together in general, the safer that environment is with respect to spreading a viral illness. Think of welders who are right next to each other in a closed space with a group of people side by side. Obviously the risk of spreading an illness is much greater given the proximity to other individuals that could have an illness.

By nature, with that kind of isolation for some workers on wind farms, the separation is an added benefit of being able to work in those environments.

▀ Have there been any extra safety measures put in place to help the wind industry deal with the pandemic?

The approach is not significantly different. It's all of these other measures that we put into place being adapted to a different project site. We know it's a remote environment. But we still want to make sure we are minimizing the risk as much as possible, so when somebody goes off site into that location, we want to know if they have signs or symptoms consistent with COVID-19, or if they've been recently exposed to somebody with COVID-19.

Now, there are some logistical challenges given just the type of work that's happening when you've got a wind farm

that stretches over many square miles, so it's obviously operationally challenging to get somebody who is sick to a first aid station.

We select medics who have the clinical and operational experience of working in these environments. In addition, we want them to be able to recognize somebody who is sick with signs and symptoms of COVID-19 and get them safely — and safely means wearing all appropriate PPE, masking the potentially sick individual as well if practical — moving them to that first aid station. There, they can have a more detailed examination to determine the level of COVID-19 symptoms and then appropriate management decisions can be made.

COVID-19 isn't a type of illness whereby somebody suddenly becomes acutely ill. It's not a catastrophic illness up-front. It is a slow, progressive illness over time that usually displays symptoms over seven to 10 days, so if somebody is going to get really sick, that's when they get really sick. Our job is less geared toward managing that really sick person, but rather in identifying somebody in a remote environment that could have symptoms and getting that person the medical care they need or preventing them from getting sick in that challenging environment. But also, a primary goal is to protect the rest of the workforce operating there.

► **Perhaps someone has mild symptoms, and they're a wind technician, and they're 100 meters up in the air, and then they start to get dizzy. What happens when a technician doesn't think he's a risk because he's working alone, and symptoms put him in possible danger?**

You're right. You've seen the laundry list of symptoms. It could be anything — headache, coughing, runny nose, nausea, vomiting, loss of taste or smell, to more significant stroke-like symptoms, blood clots, respiratory failure, or organ damage. We don't take any chances. If we're worried that somebody has any signs or symptoms consistent with COVID-19, regardless of the relative isolation of that individual, we need to move that person. I don't like to make a decision that's going to have a significant operational impact, but regardless of that operational impact, at the end of the day, we have to do what's right for that person.

And we have to value the health and safety of that person, so we're making decisions that we feel are based in evidence and are best for that individual. We want to make sure wind technicians can work; this is their livelihood. They want to be out there, and they have minor symptoms, or they have a little cough. It's just not a chance that we can take. We make those decisions understanding the potential impact to the rest of the project, even with the relative isolation, but also the safety of that individual working at height in a very complex environment.

► **Do you see industrial complexes such as wind returning to a status quo after COVID-19, or do you see all these increased measures becoming the new normal for the future?**

That's a great question. It's a little bit of trying to predict the future, because there are a lot of unknowns. We have several COVID-19 vaccines starting to be used, but this is not going to be a switch. This is a tremendous accomplishment to create safe and effective vaccines in the timeframe that we've done this, as well as to deploy this over a global population in the timeframe we're looking to do it. But there are a lot of questions that remain in terms of: Is this going to be a seasonal issue whereby we need to get boosters every year? Is this going to be something where we get enough people vaccinated, where we're going to have herd immunity? Will the virus not mutate? Will it go away after about a year?

A lot of questions remain unanswered today. The vaccine is going to be used in a targeted, phased-out approach where it will go to help essential workers and people who need it most first. I think this will include workers in critical infrastructure, but this will depend on region. A lot of that still remains to be seen in terms of how and when they get vaccinated.

But even when that happens, not everybody in the world is going to be vaccinated. It's going to require a slow, phased approach in order to get enough people across the globe vaccinated, to develop herd immunity. The best-case scenario is that COVID-19 just dies out as you get that herd immunity. But again, it's not going to be a switch. This is going to be a prolonged process — at least over the next year would be my opinion. So, these enhanced safety measures are still going to be critical. You're still going to need to identify somebody who has signs and symptoms.

You're going to want to manage them appropriately, protect the rest of your workforce, and include all the enhanced safety measures we spoke about. But I do think over time, when we see the evidence behind this and the kind of natural cycle of COVID-19 with vaccinations, that in the future, it may change. Some of the measures such as enhanced hand hygiene and maintaining some degree of distance are probably going to last a long while before they change.

And the psychological impact is going to be around for a long while. Much of it is going to be ingrained in us. We are going to naturally carry that into our environments. Like now, instead of coughing and sneezing into our hands, we're going to do it into our arms. We are going to wash our hands a lot more often and more thoroughly than we would have before. And we're going to be much more aware of illness in general, because we're going to be afraid of the next COVID-19, the next pandemic. ↴

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The Haystack project includes the supply of 51 SG 5.0-145 wind turbines and 18 safe harbor turbines. (Courtesy: Siemens Gamesa)

► CONSTRUCTION

Siemens Gamesa, Ørsted sign first U.S. onshore project

Siemens Gamesa has signed a milestone wind-power agreement with Ørsted to supply the 298-MW Haystack wind farm in Nebraska as the two companies embark on a new stage in their onshore partnership following nearly 30 years of offshore projects together.

The Haystack project includes the supply of 51 SG 5.0-145 wind turbines and 18 safe harbor turbines. The first deliveries are expected to begin in the summer of 2021 with commissioning expected in fourth quarter 2021.

The order also includes a 30-year

full-scope service and maintenance agreement covering primary activities related to the service and maintenance of the units. This agreement is the longest ever service contract for Siemens Gamesa in North America and evidences trust not only in Siemens Gamesa's technology but also the company's strong and flexible service capabilities.

"Ørsted is a key partner in our offshore business, and we are excited to expand that partnership into onshore wind power. The Haystack project will provide clean energy to nearly 85,000 average U.S. homes," said Shannon Sturgil, CEO of Onshore North America at Siemens Gamesa Renewable Energy. "We achieved an important milestone over the summer with the Coastal Virginia Offshore Pilot Project, and we are thrilled to add Haystack to

our list of firsts."

The SG 5.0-145 wind turbine from Siemens Gamesa, to be used at the Haystack project, has proven to be a very successful product in the U.S. Its new state-of-the-art control system and enhanced blade aerodynamics optimize power generation. Thanks to its OptimaFlex technology, the wind turbine also features a flexible power rating ranging between 4.0 and 5.0 MW, thereby providing a uniquely tailored solution that fits the specific conditions of each site. The turbine features a modular design for increased mechanical capacity and optimal adaptation to logistics and construction requirements, providing greater efficiency and lower levelized cost of energy (LCOE).

The Coastal Virginia Offshore Wind pilot project, which came online

this summer, is owned by Dominion Energy and Ørsted is EPC contractor on the project. It is the first offshore wind project in U.S. federal waters and the first offshore wind project in the U.S. for Siemens Gamesa, located approx. 27 miles/43.5 km offshore.

Together, Siemens Gamesa and Ørsted have installed more than 1,300 offshore wind turbines. This order expresses confidence in Siemens Gamesa's technology and service.

In total, Siemens Gamesa has installed more than 23 GW in the U.S. and has a strong U.S. footprint consisting of manufacturing, service and offices. With nearly 72 GW under service globally, including more than 10 GW of multi-brand turbines, Siemens Gamesa is a leading service provider in the industry. In North America, Siemens Gamesa provides service and maintenance to wind projects with a total output capacity of more than 14 GW.

MORE INFO www.siemensgamesa.com

► CONSTRUCTION

North Sea Energy establishes conditions for offshore growth

Offshore wind energy plays an important role in making Dutch energy supply more sustainable and achieving climate objectives. The 2030 Offshore Wind Energy Roadmap provides a blueprint on how and where new wind farms will be built in the period up to and including 2030. But what role will offshore wind energy play in the period after that? And under which conditions can offshore wind energy help to increase sustainability in the 2030-2050 period? The North Sea Energy Outlook (NEO) provides a scientifically based overview of the possibilities for using the North Sea to increase sustainability after 2030, while providing insight into opportu-



About 70 percent of current electricity consumption is expected to come from wind and solar energy in 2030, more than half of which will be produced by offshore wind farms. (Courtesy: DNV GL)

nities for further growth of offshore wind energy and its consequences for the national energy system. The report was drawn up by DNV GL on behalf of the Ministry of Economic Affairs and Climate Policy.

About 70 percent of current electricity consumption is expected to come from wind and solar energy in 2030, more than half of which will be produced by offshore wind farms. The NEO concludes that due to its potential for wind-energy development and CO₂ storage, the North Sea is also indispensable when it comes to achieving the climate target of a 95 percent reduction in CO₂ emissions by 2050. Wind energy will have to grow significantly after 2030 to achieve that target. If offshore wind energy is to grow successfully after 2030, however, the right preconditions must be met.

ENERGY SYSTEM INTEGRATION

One important precondition for the growth of offshore wind energy after 2030 is the electricity generated must be properly integrated into the energy system. This means the required infrastructure (such as cables and substations) must be available in good time. It is therefore important for the spatial planning of wind farms that the landfall and land-based infrastructure to

be properly coordinated. This is why an analysis of landfall options for offshore wind 2030-2040 (the 'VAWOZ' project) was scheduled to start December 9. This project forms the link between the North Sea 2022-2027 program, which focuses on marine spatial planning and the National Energy Network Program, which focuses on the spatial planning for the main energy system on land. New areas for offshore wind energy will be designated (in line with the agreements from the North Sea Agreement) after careful consideration of all interests in the North Sea in the North Sea 2022-2027 program. An integral part of this assessment includes carrying out an environmental impact assessment (EIA Plan) and incorporating the results from the Offshore Wind Ecological Program (WOZEP).

SUFFICIENT DEMAND

The NEO also states the market will only be willing to make ongoing and scaled-up investments if there is a healthy and stable business case for sustainable energy producers. In concrete terms, this means more insight is required into the development of demand for renewable electricity and green hydrogen, and this demand must increase in good time. A signifi-



Georgia Tech and Logisticus will conduct research and development to commercialize mass-market architectural, engineering, and construction products from repurposed FRP composite of decommissioned wind turbine blades. (Courtesy: Georgia Tech)

cant part of the expected demand will be due to sustainability improvements being made in the industry. The European Emissions Trading System (ETS), minimum CO2 price, and National Sustainable Industry Infrastructure Program (PIDI) are initiatives designed to encourage industry to invest in sustainability. In addition, in response to the recommendation of the Industry Climate Agreement Infrastructure Task Force (TIKI), the government has announced an Electrification Roadmap (technology outlook) to be published in early 2021, which should provide more insight into the demand for green electricity from industry.

The approach to the rollout of new wind farms will be updated so the energy generated at sea can be linked to expected demand. Stakeholders will be involved in the development of this new approach and relevant insights will be used, including those from the Guidehouse report on integrated tenders for offshore wind energy and hydrogen production. The North Sea Energy Outlook by DNV-GL and the study into combined offshore wind and hydrogen production by Guidehouse are appendices to the letter to parliament about the NEO.

MORE INFO english.rvo.nl/topics/sustainability/offshore-wind-energy

INNOVATION

Logisticus teams with Georgia Tech for blade re-use project

Wind turbines are, by design, green solutions for the production of power. Wind turbines produce zero carbon emissions; however, the blades themselves pose an environmental challenge as the blades depreciate. To address this concern, the Georgia Institute of Technology in partnership with Logisticus Group was awarded the U.S. National Science Foundation (NSF) Partnerships for Innovation (PFI) grant.

The Partnerships for Innovation Program within the Division of Industrial Innovation and Partnerships (IIP) provides researchers from science and engineering disciplines funded by the NSF with the opportunity take their research and technology from the discovery phase to the marketplace for the benefit of society.

Russell Gentry, professor in the Georgia Tech School of Architecture, serves as the project's principal investigator. The three-year grant continues Gentry's research on the reuse of retired wind blades and builds on the proprietary technology developed as part of the Re-Wind Tripartite Research program funded by the U.S. NSF, Science Foundation of Ireland, and the Department for the Economy of Northern Ireland.

"In our foundational NSF grants, our team demonstrated the potential for wind-blade re-use and the positive environmental benefits that will come from the re-use of these amazing composite materials in civil infrastructure," Gentry said. "This potential is embodied in the two patents we are pursuing and in the follow-on Partnership for Industry grant from NSF. The team is now advancing our hardware and software technology and has partnered with companies in the wind energy and electrical transmission industries to pilot these technologies."

Logisticus Group joins the project as the key provider of transportation for the retired wind-turbine blades. As one of the largest wind-blade transporters, Logisticus Group brings supply expertise for the complex logistics of transporting decommissioned wind-turbine blades, which are approximately 50 meters in length.

"We are thrilled to partner with Georgia Tech on this project," said Will Stephan, founder of Logisticus Group. "Their team has always had a passion to conduct research and development on proprietary technology when it comes to reusing wind blades. We feel, as a company, that we need to be a part of the solution to find ways to recycle and repurpose these blades."

Wind-turbine blades are made from high quality fiber-reinforced polymer composite materials, which are not biodegradable or recyclable. Currently, turbine blades are landfilled or incinerated at their end-of-life stage. Georgia Tech and Logisticus will conduct research and development to commercialize mass-market architectural, engineering, and construction products from repurposed FRP composite of decommissioned wind turbine blades.

The team, comprised of Georgia Tech faculty, laboratory staff, and graduate and undergraduate students in architecture and engineering, will develop commercial products using Generative Design software, architecture studios and workshops, structural and Finite element analysis, life-cycle analysis, Lidar technology, and full-scale testing of prototypes in Georgia Tech's 20,000 sq. ft Digital Fabrication Laboratory.

"The success of our project comes from the diverse talents and viewpoints represented on the team," Gentry said. "It's rare to have architects, engineers, and social, geospatial, and environmental scientists working on the same fundamental problem. As we move to commercialize, we are building an entrepreneurial team and linking with industry. We look forward to seeing our re-use applications implemented in the next three years."

Prior to receiving the NSF PFI



In addition to the recyclability aspect, thermoplastic resin can enable longer, lighter-weight, and lower-cost blades. (Courtesy: NREL)

grant, researchers at Georgia Tech developed proprietary algorithms for a tool called the “Blade Machine” and created unique testing methodologies to rapidly characterize any wind-turbine blade currently in production for architectural and structural analysis and design purposes.

In October 2020, the team participated in the NSF’s I-Corp Innovation Program.

MORE INFO www.logisticusgroup.com

► INNOVATION

NREL research moves wind-turbine blades toward recyclability

A new material for wind blades that can be recycled could transform the wind industry, rendering renewable energy more sustainable than ever before while lowering costs in the process.

The use of a thermoplastic resin has been validated at the National Re-

newable Energy Laboratory (NREL). Researchers demonstrated the feasibility of thermoplastic resin by manufacturing a 9-meter-long wind-turbine blade using this novel resin, which was developed by Pennsylvania company, Arkema Inc. Researchers have now validated the structural integrity of a 13-meter-long thermoplastic composite blade, also manufactured at NREL.

In addition to the recyclability aspect, thermoplastic resin can enable longer, lighter-weight, and lower-cost blades. Manufacturing blades using current thermoset resin systems requires more energy and manpower in the manufacturing facility, and the end product often winds up in landfills.

“With thermoset resin systems, it’s almost like when you fry an egg; you can’t reverse that,” said Derek Berry, a senior engineer at NREL. “But with a thermoplastic resin system, you can make a blade out of it. You heat it to a certain temperature, and it melts back down. You can get the liquid resin back and reuse that.”

Berry is co-author of a paper titled, “Structural Comparison of a Thermo-

plastic Composite Wind Turbine Blade and a Thermoset Composite Wind Turbine Blade,” which appears in the journal *Renewable Energy*.

The other authors, also from NREL, are Robynne Murray, Ryan Beach, David Barnes, David Snowberg, Samantha Rooney, Mike Jenks, Bill Gage, Troy Boro, Sara Wallen, and Scott Hughes.

NREL has also developed a techno-economic model to explore the cost benefits of using a thermoplastic resin in blades. Current wind-turbine blades are made primarily of composite materials such as fiberglass infused with a thermoset resin. With an epoxy thermoset resin, the manufacturing process requires the use of additional heat to cure the resin, which adds to the cost and cycle time of the blades. Thermoplastic resin, however, cures at room temperature. The process does not require as much labor, which accounts for about 40 percent of the cost of a blade. The new process, the researchers determined, could make blades about 5 percent less expensive to make.

NREL is home to the Composites Manufacturing Education and Tech-

nology (CoMET) Facility at the Flatirons Campus near Boulder, Colorado.

“The thermoplastic material absorbs more energy from loads on the blades due to the wind, which can reduce the wear and tear from these loads to the rest of the turbine system, which is a good thing,” Murray said.

The thermoplastic resin could also allow manufacturers to build blades on site, alleviating a problem the industry faces as it trends toward larger and longer blades. As blade sizes grow, so does the problem of how to transport them from a manufacturing facility.

This work was funded by the U.S. Department of Energy Advanced Manufacturing Office. NREL is the U.S. Department of Energy’s primary national laboratory for renewable energy and energy efficiency research and development. NREL is operated for the Energy Department by the Alliance for Sustainable Energy, LLC.

MORE INFO nrel.gov

INNOVATION

EDF France adopts ONYX Insight inspection technology

French energy leader EDF Renewables France has equipped its asset managers working across all their wind assets with fieldPRO, an advanced cloud-based inspection and service tool from ONYX InSight, a leading provider of data analytics and engineering expertise to the global wind industry. This follows the partnership with EDF Renewables North America for ONYX InSight’s Condition Monitoring solutions, including cloud-based system fleetMONITOR and retro-fit ecoCMS hardware installations.

The deal, initially for three years, covers all 1,675 MW of EDF Renewables’ wind assets in France and is a first for the French wind market, further strengthening ONYX InSight’s footprint in Europe. The use of fieldPRO



ONYX InSight worked with EDF Renewables France to tailor the interface of the software platform to specifically support and align with its requirements. (Courtesy: ONYX InSight)

circumvents the need for paper-based solutions, enabling EDF Renewables France’s asset managers to digitally document and automate the inspection process, streamlining image categorization with indexed photos and auto-generated reports.

The application’s cloud capability enables instant data sharing in a clean, consistent format, improving the availability, usability, and accuracy of the inspection and survey data. Inspection data is key to enabling successful, long term predictive maintenance strategies. Traditional offline inspections, despite delivering valuable information on turbine health, are often siloed and filed away on paper, making it difficult to access and extract insights; fieldPRO automatically stores and organizes inspection information in a digital format, resulting in improved oversight and better decision making.

The fieldPRO tool also provides critical health and safety support by enabling remote inspections and validation of procedures, particularly around personal protective equipment, which helps to ensure safety for technicians on site. More broadly, fieldPRO provides a useful checklist for on-site personnel, supporting safe working best practices and ensuring nothing is missed.

ONYX InSight worked with EDF Renewables France to tailor the interface of the software platform to specifical-

ly support and align with its requirements.

“FieldPRO has a huge potential to improve the way we work by setting best practices and automating a lot of our procedures,” said Soraya Zobiri, asset manager for EDF Renewables France. “Our journey to provide clean energy at the lowest cost is ultimately driven by efficiency gains, and we are confident that, by partnering with ONYX InSight, we will continue to deliver ever-more affordable clean energy.”

“We know from years of experience that the reality of collecting inspection data and managing field operations can be complex and time consuming,” said Keiran Knowles, business development manager Northern Europe for ONYX InSight. “Our fieldPRO tool allows operators greater oversight of this crucial part of operations and maintenance, while removing the burden from technicians having to spend valuable time in sorting through hundreds of inspection points and photos and writing laborious reports. Instead, this technology facilitates scheduling and workorder assignment, while streamlining data collection for improved planning, safety, and logistics.”

“Adopting mobile digitization tools unlocks the most accurate data analytics yet,” he said. “Inspection data is the next frontier in the complete digitalization of the global wind fleet, and we are proud to support pioneers such as EDF Renewables France as they contin-

ue to drive down the cost of producing clean energy.”

MORE INFO www.onyxinsight.com

MAINTENANCE

Sealing solution meets challenges of larger turbine designs

Global sealing technology expert James Walker has launched a new innovative version of its Walkersele® rotary lip seal, following an in-depth research and development project in collaboration with wind-turbine and bearing OEMs.

The new product, Walkersele® X-Gen, meets the challenges of the increasing size of turbine designs — maintaining effective sealing against deflected shafts or housings and increased offset, plus enhanced retention of sealing forces over the full circumference of the sealing face.

Walkersele X-Gen also addresses the issues created by the use of high-performance greases for lubrication rather than oil, which brings a new dynamic to the operation of the bearing seal and an additional challenge for any sealing solution.

In cooperation with bearing and turbine OEMs, James Walker has undertaken a comprehensive test program covering all elements of rotary seal design.

These include spring retention, lip loading, torque, friction, leakage and wear, plus sealing capability at a variety of significant offsets. Testing was focused on protecting and extending the service life of critical bearing applications and drive mechanisms.

The result is a new patented seal construction specifically configured to optimize sealing capability on large diameters where increased levels of offset from loaded bearings and out-of-round shafts and seal housings can create significant issues.

MORE INFO www.jameswalker.biz



The new patented design of the Walkersele X-Gen incorporates a refined lip design, molded-in finger spring, and innovative fiberglass-reinforced backing. (Courtesy: James Walker)

MAINTENANCE

Reygar to enhance tech safety, comfort at offshore projects

Reygar, a leading provider of advanced monitoring systems to the offshore renewable energy sector, has been commissioned to develop an industry-first motion comfort monitoring tool capability within BareFLEET, Reygar's innovative remote monitoring and reporting platform. The new tool will track and analyze motion, fuel consumption, and crew sickness in different cabin locations, with a specific focus on boosting safety and fitness to work aboard vessels supporting critical multi-day work at Siemens Gamesa projects.

The proliferation of large, remote offshore wind projects — particularly in regions characterized by challenging sea conditions — has only increased the need for greater granularity around vessel data. To service these projects, technicians are required to spend more time at sea — often multiple consecutive days. It is therefore crucial that offshore wind vessel operators are able to ensure the wellbeing of the crew and technicians they transport to these projects is protected.

The BareFLEET system Siemens Gamesa has commissioned automatically monitors the health and perfor-

mance of critical equipment across each vessel, inclusive of engine health, CO2 emissions, fuel consumption, motion, and impact on the turbine. The system also allows the crew to manually input supplementary data and observations into a customer-specific digital reporting platform, with the resulting DPR form customized to bring Siemens Gamesa's own key performance indicators and priority data fields — such as crew comfort — to the fore.

“As wind projects move further offshore into areas of higher wind resource, it is paramount that charterers and vessel operators are equipped with the true understanding of vessel motions and personnel comfort they need to keep these projects — and the people constructing and maintaining them — performing at their best,” said Chris Huxley-Reynard, managing director of Reygar Ltd. “Motion data measured across different cabin locations and different vessels, sourced via BareFLEET while in transit and while idling, will advise Siemens Gamesa's chartered vessel operators on how to guarantee the crew and technicians are housed and transported in such a way that they can continue do their jobs effectively across multi-day projects.”

“With the global energy transition well underway, we are increasingly focused on how digitalization can power the efficient and safe roll-out of our



The BareFLEET system automatically monitors the health and performance of critical equipment across each vessel, inclusive of engine health, CO2 emissions, fuel consumption, motion, and impact on the turbine. (Courtesy: Reygar)

technology across projects in exciting, rapidly growing markets such as the U.S. and Taiwan,” said René Wigmans, head of Offshore Service Logistics for Siemens Gamesa. “Our work with Reygar to further integrate BareFLEET’s detailed motion reporting into our offshore activity will support our team in maximizing operational efficiency and reducing vessel CO2 emissions whilst securing the health and comfort of our crew as they work on these flagship – yet often remote – sites.”

MORE INFO www.reygar.co.uk

MAINTENANCE

Guardian Fall Protection unveils cable lanyard

Pure Safety Group’s Guardian® Fall Protection brand has introduced a new cable lanyard – compatible for leading edges – that combines the lightweight

durability of a fixed-length lanyard that permits up to 12 feet of fall protection during the event of a free fall from an at-height working surface.

Through extensive research and development in Guardian’s ISO/IEC:10725-compliant laboratory, the company established rigorous leading-edge verification testing procedures to ensure consistent performance of the lanyard over a wide range of extreme conditions. Drop-tested in both a perpendicular and offset orientation against 0.005-inch radius steel, the Guardian Cable Leading Edge Lanyard exhibited high performance and predictability – two characteristics mandatory when it comes to fall protection.

The Cable Leading Edge lanyards feature a vinyl-coated quarter-inch galvanized steel cable, combined with Guardian’s proprietary high-efficiency external shock absorber that keeps maximum and average arrest forces low during fall deceleration.

Cable Leading Edge lanyards are available in single- or dual-leg configurations with steel rebar or snap hooks.



The Guardian Cable Leading Edge lanyards feature a vinyl-coated quarter-inch galvanized steel cable, combined with Guardian’s proprietary high-efficiency external shock absorber. (Courtesy: Pure Safety Group)

A high-visibility orange shock pack cover helps confirm proper application suitability, even from a distance.

MORE INFO www.puresafetygroup.com

MANUFACTURING

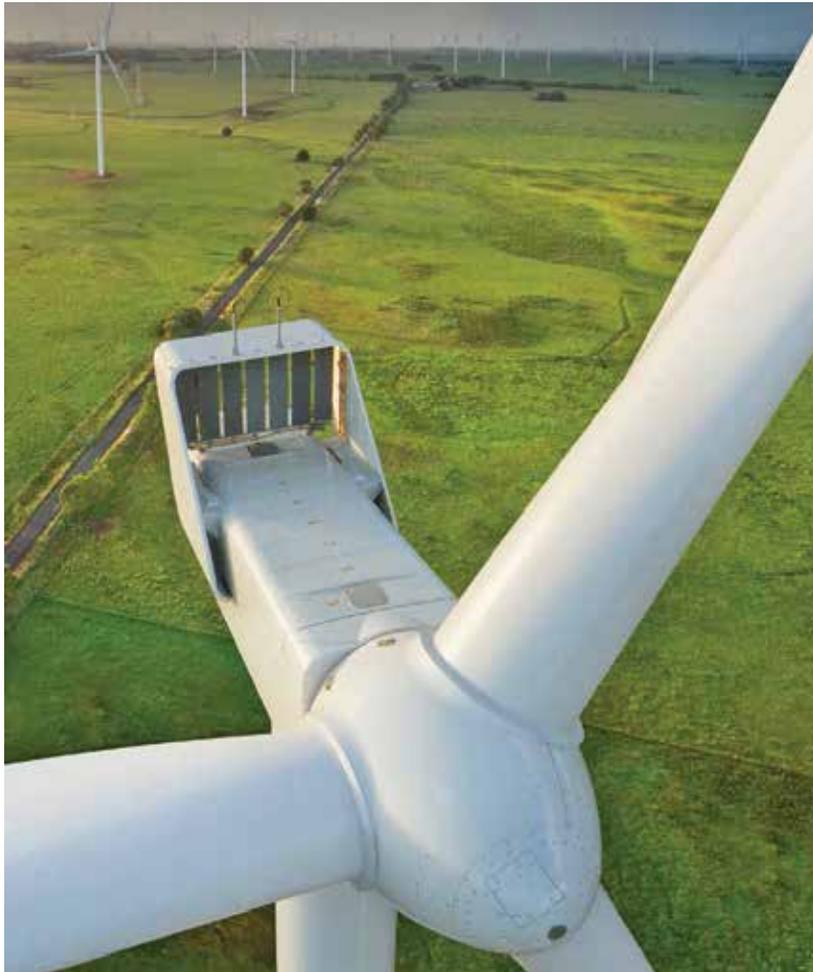
Vestas wins 234-MW order with EnVentus turbines in the U.S.

Vestas has received a 234 MW order for two projects in the U.S. The two projects consist of 32 V150-4.2 MW turbines delivered in 4.3 MW Power Optimized Mode, 15 V162-6.0 MW EnVentus turbines as well as eight V110-2.0 MW turbines, including 10 MW of previously purchased 2 MW PTC components.

The order includes supply and commissioning of the turbines as well as multi-year service agreements for both projects, designed to ensure optimized performance for the lifetime of the project. Turbine delivery is scheduled for the third and fourth quarter of 2021 with commissioning scheduled for the fourth quarter of 2021 and first quarter of 2022.

“We’re glad to expand the EnVentus portfolio in the U.S.,” said Eduardo Medina, president of Vestas’ sales and service division in the United States and Canada. “The EnVentus platform builds on our proven technology from the 2-MW, 4-MW, and 9-MW platforms to leverage proven technology and increase customized solutions to extract wind value around the world.”

This EnVentus order takes the glob-



Two U.S. projects will use of 32 V150-4.2 MW turbines. (Courtesy: Vestas)

al order intake for the platform past 1,200 MW.

The customer and projects are undisclosed per the customer's request.

MORE INFO www.vestas.com

MANUFACTURING

OM System launches software to aid COVID-19 response

OM System recently launched its cloud-based outbreak management software as the easiest way for businesses to manage COVID-19 response efforts and containment in a closed

environment. The platform features a dynamic visualization called BirdsEye View™ enabling rapid assessments to spot and stop outbreaks. Born as COVID-19 altered the reality of workplace safety, the system empowers employers with a tool to optimize their outbreak management strategy and get back to work with confidence.

Essential businesses have continued to operate through the height of the pandemic and continue to do so. Running and resuming operations comes with risk, liability, and responsibility, and it is imperative that all businesses have a comprehensive and transparent COVID-19 strategy. Manual processes, spreadsheets, and uncoordinated solutions are insufficient.

“When the worldwide crisis of

the COVID-19 pandemic descended upon us all, we at OM System saw an immediate opportunity to serve,” said Chris Hawker, CEO of OM System. “We pivoted one of our existing solutions and created a powerful tool to visually manage and isolate infectious diseases, not just for the current pandemic, but for the upcoming flu season and beyond.”

“OM System has three distinct parts: a communications system with the employees, a secure database, which stores and tracks information, and our BirdsEye View™ that allows employers to rapidly assess the health of the organization and save significant time anticipating and intervening in outbreaks,” he said.

HOW OM SYSTEM WORKS

▀ **System setup:** Employee contact records are securely uploaded and organized in OM System by workgroups (shifts, departments, buildings, sites, etc.), implemented and ready to use in a matter of hours, not weeks.

▀ **Daily check-in:** Via centralized check-ins or mobile app, employee health statuses can be captured with notification of their approval to be on-site.

▀ **Case creation:** Once a company-defined health risk threshold is met, a case is created, ensuring visibility and follow-up.

▀ **Case investigation:** With simple entry of exposures and OM System's BirdsEye View™ visualization, outbreaks become easy to spot.

▀ **Employee outreach:** Employees who may have been exposed are alerted via text or email, with support and measures they can take while maintaining the privacy of all employees.

▀ **Outbreak managed:** OM System provides visualization, reporting, trends, and simplified communication to keep employees safe.

▀ **Risk managed:** The platform also helps employers manage risk and compliance as the tool has been developed with OSHA & CDC guidelines in mind. ✎

MORE INFO www.omsystem.io

CROSSWINDS

THE FUTURE OF WIND

OCEANBIRD SHIP TRAVELS ON WIND

Oceanbird will have five 80-meter (262 feet), fully rotational wing sails - twice the height of masts on the largest conventional sailing vessels on the seas today. With a height above water line of about 105 meters (340 feet), it may be the tallest ship in the world. (Courtesy: Wallenius Marine)

Emission-free, wind-powered merchant vessels may soon cross oceans using a system of vertical composite ‘wings’ instead of sails.

By EDWARD LUNDQUIST

Wind has revolutionized the energy industry with its source of sustainable, emission-free power. Now, wind is being harnessed to power merchant ships across oceans.

A new type of sailing ship is emerging, but this modern version looks nothing like the ships that crisscrossed the world’s oceans during the “age of sail.”

Oceanbird, an automobile-carrying cargo ship with a capacity of 7,000 cars, features vertical metal or composite “wings” to harness wind energy for propulsion. They will be raised and lowered telescopically and will be fully rotational and autonomously controlled. When fully extended, the wings will be much higher than the tallest point on traditional ships. The wings can be retracted in harbors and to travel under bridges. The design features diesel engines for entering and leaving port and to augment the sails to maintain schedules.

GOVERNMENT-FUNDED TEAM

A Swedish consortium of industry, academia, and research organizations has partnered to create the wind-powered car carrier (WPCC) by 2021. Wallenius Marine is showcasing its concept for the *Oceanbird*, an automobile-carrying cargo ship with a capacity of 7,000 cars. The company is leading a government-funded team studying wind-powered ships, along with a Swedish consortium of the Royal Institute of Technology (KTH) Centre for Naval Architecture, and maritime tech developer SSPA.

Per Tunell, COO of Wallenius Marine, said the wind-powered car carrier project changes the prerequisites for ocean-going sea transportation.

“The industry faces enormous challenges in terms of sustainability, and this type of solution with wind-powered ships on the oceans is by far the most interesting solution for achieving truly sustainable shipping,” he said.

Wind-powered car carriers will be slower than the current fleet of 450 conventionally-powered car carriers in service today. For example, they take seven or eight days to cross the Atlantic, where the WPCC would take 12. But the tradeoff is vastly reduced fuel costs and emissions. Contemporary car transporters burn about 40 tons of fossil fuel per day.

REDUCING SHIP EMISSIONS

The International Maritime Organization (IMO) has established a goal of reducing overall merchant ship carbon emissions by half by 2050. But the WPCC team is aiming even higher.

“We are going much further and aiming for a reduction of 80 to 90 percent,” said Professor Jakob Kuttenkeuler of the KTH Centre of Naval Architecture in Stockholm. “This en-

tails a paradigm shift as today’s ships travel far too fast and with high fuel consumption. We are developing the world’s first emission-free shipping concept in modern times.”

A group of KTH students are building a seven-foot scale model of the WPCC.

“Our physical model is a real test bed for control algorithms and learning more about maneuvering,” Kuttenkeuler said. “We are equipping our model with very good – and expensive – instruments, such as anemometers and dual-antenna GPS systems, so it will be a functional testbed for maneuvering experiments. We’re building four rigs – although *Oceanbird* will have five. We’ll mount them on our seven-meter boat with the fittings, actuators, bearings, and control systems.”

MERGING AEROSPACE AND MARINE INNOVATIONS

The challenge of using wind to propel a ship on the water is well understood, but Kuttenkeuler said the WPCC design is a blend of both aerospace and marine engineering.

“The rigging should be aerodynamically optimized, robust, light, and cheap to manufacture,” he said. “It can be likened to designing sailing mechanics for an airplane that is going to be tossed about at sea.”

But the WPCC concept is altogether different and involves an entirely new area of the sea-atmosphere interface.

“We’ve been using sailboats for thousands of years, but only in the very lowest part of the atmosphere,” Kuttenkeuler said. “They use the wind from the waterline to about 30 meters. No one has ever sailed using the atmosphere from 50 to 100 meters that we are going to use. It’s actually a very



Oceanbird’s “wings” can be raised and lowered telescopically and will be fully rotational and autonomously controlled. (Courtesy: Wallenius Marine)



Students at KTH Centre of Naval Architecture built a scale model of the wind-powered car carrier (WPCC) for at-sea testing. The 11 naval design students fabricated a seven-meter WPCC model to validate the ship's center of gravity and also tested the propulsion and steering. (Courtesy: Wallenius Marine)

different environment.”

Even offshore wind turbines don't go that high, Kuttenukeuler said, and most wind turbines are located near the shore for obvious reasons.

“Oceanbird will sail in the middle of the ocean, so we need knowledge that really doesn't exist right now,” he said. “There isn't much data or analysis of that part of the



Hydrodynamic testing of a 1:25 scale WPCC hull was conducted at the SSPA towing tank. (Courtesy: Wallenius Marine)

atmosphere. We have had to do a lot of it ourselves.”

IDENTICAL WINGS

According to Sjoerd Jan Sinnema, the student leader for the KTH WPCC cohort, each of the wings will be identical, with the same profile and layout, but each wing will attack the wind at the most efficient angle.

“We are implementing anemometers to help determine the optimal angle and wind flow for each wing, so the wings will be able to provide the most forward momentum,” he said.

The project has left a lasting impression on Sinnema. “The most important thing I learned from partaking in



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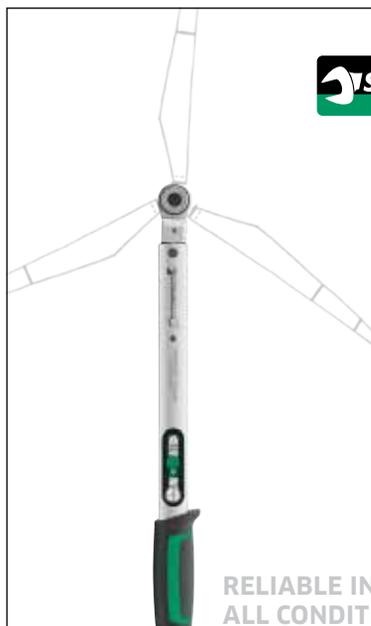
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CROSSWINDS

THE FUTURE OF WIND



Each of the wings on the Oceanbird will be identical, with the same profile and layout, but each wing will attack the wind at the most efficient angle. (Courtesy: Wallenius Marine)

this ambitious effort is that, when it comes to sustainable development, especially in the shipping industry, even the craziest ideas can become reality when there is enough motivation and collaboration between the collective of organizations and companies to turn an idea into reality," he said. "Maybe at first it seemed kind of like a 'pie in the sky' idea. Producing our demonstrator over the last nine months really shows that this propulsion system could indeed be one of the solutions to make it to market."

\$3 MILLION GRANT

The Swedish Transport Administration is backing the WPC research consortium with a \$3 million grant. The research effort will run until 2023.

KTH will provide aerodynamic and sailing mechanics expertise, including calculations of performance and route optimization, and fabrication of a seven-meter scale model for in-water testing.

Naval architecture students at KTH tested their model at Viggbyholm, north of Stockholm. According to Ulysse Dhomé, project supervisor at KTH, the "sea trials" were very useful.

"Now we know more precisely how the boat will behave, and we can cal-

culate how to make it stable," he said.

SSPA will use its tow tank facility in Gothenburg, Sweden, to conduct hydrodynamic modeling and testing of a 1:25 scale model for validation of concepts and designs.

"We have done extensive computer simulations," said Sofia Werner, manager of Strategic Research Hydrodynamics at SSPA. "Now we need to confirm these simulations with the experiments to get more accurate numbers of the performance and the forces acting on the ship."

The consortium partners see a bright future.

"We are creating a Swedish competence cluster of wind-powered vessel development and design," said Vendela Santén, senior researcher and project manager at SSPA. "Together we are stronger."

The team said the wind concept can be applied to other types of ships in the future. ✎

ABOUT THE AUTHOR

Edward Lundquist is a retired Navy captain and writer on naval, maritime, defense, energy, and transportation issues. He lives in Springfield, Virginia.

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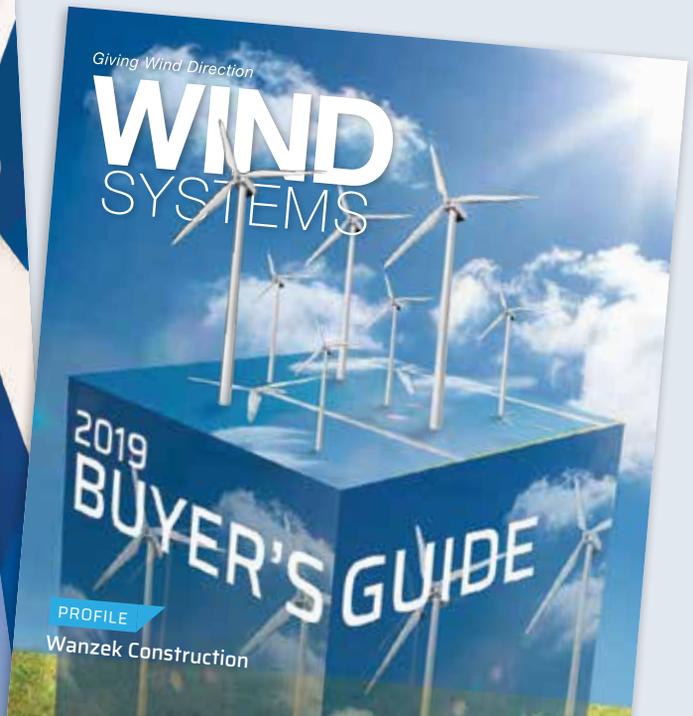
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- ERAD DIGITAL TORQUE CONTROL SYSTEMS
- ELECTRIC GEAR TURNING SYSTEMS
- WTG SPECIFIC BOLT TENSIONING SYSTEMS
- HYDRAULIC WRENCH SYSTEMS
- WTG SPECIFIC SELF LOAD INDICATING FASTENERS

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