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Head of Wind Operations at Vaisala

JULY 2024
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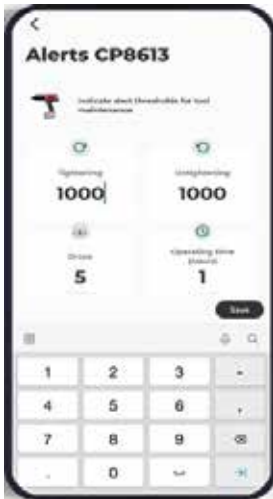
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BEATING THE HEAT

By combining acclimatization protocols, wearable technology, weather-based work modifications, and heat safety training, employers can minimize the risks to workers' health and productivity.

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Wind is still going strong

Wind energy isn't going anywhere. To all who have spent years developing ways to harness power from the wind, that statement seems more than obvious.

Still, there are some doubters out there.

Which makes it all the more interesting when I hear news like this: Despite pressures on financing, global investment in clean energy is set to reach almost double the amount going to fossil fuels in 2024, helped by improving supply chains and lower costs for clean technologies, according to a new IEA report.



Total energy investment worldwide is expected to exceed \$3 trillion in 2024 for the first time, with some \$2 trillion set to go toward clean technologies – including renewables, electric vehicles, nuclear power, grids, storage, low-emissions fuels, efficiency improvements and heat pumps – according to the latest edition of the International Energy Agency's annual World Energy Investment report. The remainder, slightly over \$1 trillion, is going to coal, gas and oil. In 2023, combined

investment in renewable power and grids overtook the amount spent on fossil fuels for the first time.

Great news for wind and all renewables. That steady growth in renewables also means that the products and services needed to get those turbines built and spinning are more important than ever.

In our July issue, we take a closer look at some of these topics: towers, safety, and cables.

Our lead inFocus article from Kenzen's Kyle Hubregtse and Nick Hernandez looks at how — by combining acclimatization protocols, wearable technology, weather-based work modifications, and heat safety training — employers can minimize the risks to workers' health and productivity.

On the subject of towers, our second article looks at the need to rethink wind towers and turbines, including how wood can make wind power even greener by serving as the very material towers are constructed with.

Our final article takes on the need for safety for deep water divers who monitor and maintain underwater transmission lines and cables for offshore wind turbines and the potential hazards they may face.

You'll discover that and much more in this issue. I hope you find it informative, and please feel free to send me any feedback about what you'd like to see in future issues. I'm always looking for contributors and good article ideas.

Thanks for reading!



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Report: U.S. storage market sets record

From American Clean Power

The U.S. energy storage market set a first-quarter record for capacity installed in Q1 2024, with 1,265 MW deployed across all segments. This marks the highest storage capacity ever installed in a first quarter in the U.S., representing an 84 percent increase from Q1 2023.

According to Wood Mackenzie and the American Clean Power Association's (ACP) newly released U.S. Energy Storage Monitor report, the grid-scale segment installed 993 MW, producing the highest Q1 on record for the grid-scale segment. Nevada, California, and Texas accounted for 90 percent of new grid-scale capacity added.

"The rapid growth of the energy storage industry comes at a critical time, providing a solution to growing energy demand and increasingly variable weather conditions that are placing added stress on the grid," said John Hensley, vice president of markets and policy analysis at ACP. "A strong start to 2024 sets expectations high for the remainder of the year. We look forward to celebrating the industry's first double digit installation year and cheering the tight race for top storage state playing out between California and Texas."

The residential segment set a record for quarterly installations at 250 MW in Q1, an 8 percent increase over the previous record set in Q4 2023. California drove growth in the residential segment, installing 24 percent more than the previous quarter.

California also led the community, commercial, and industrial (CCI) segment to install 19.4 MW, which represents a 43 percent decline quarter-on-quarter (QoQ), as both New York and Massachusetts experienced one of the slowest CCI quarters in recent years.

Despite seasonal patterns of project installations resulting in a QoQ drop, Q1 installation additions of 993 MW in the grid-scale segment represent a 101 percent increase over Q1 2023.

The U.S. energy storage market is expected to see 12.9 GW deployed across all segments in 2024. New capacity additions are due to break the 10 GW mark for the first time ever, according to the report.



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

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DIRECTION

THE FUTURE OF WIND



Oceantic announces student scholarship winners

Oceantic Network recently announced three winners of its 2024 Rising Star Student Scholarship, which supports college-bound high school seniors who have demonstrated impeccable academic achievement and a keen interest in pursuing a career in offshore wind and ocean renewable energy. The 2024 scholarship winners hail from Mississippi, New Jersey, and Virginia and represent aspirations and the future of the growing U.S. offshore wind industry, with interests ranging from engineering, project management, and public policy.

The Network launched the Rising Star: Offshore Wind Student Scholarship in 2022 with proceeds from the Network's annual Ventus Gala as well as industry donations.

This year, winners were selected from more than 80 applicants and each will receive \$5,000 to use toward tuition fees. This year's recipients of the Rising Star: Offshore Wind Student Scholarship include:

▼ **Alyssa Taub:** (East Brunswick, New Jersey) Taub has been enamored with the technical side of offshore wind throughout her high school career. She took several STEM



classes, which included designing a wind turbine as part of a physics project. She showed great aptitude for physics throughout her academic career and, after a senior-year marine biology course, cannot wait to put her skills to work to create a more sustainable future studying civil engineering at The Cooper Union for the Advancement of Science and Art.



▼ **Mariah Hicks:** (Southaven, Mississippi) Hicks

served as president of her high school's Environmentalist Club. She led her team to the state competition, leveraging her understanding of offshore wind initiatives to represent the objectives of the Bureau of Ocean Energy Management's Mississippi project. By studying economics at Spelman College, she hopes to contribute to offshore wind projects that protect the environment while also being economically viable.

▼ **Shelby Huffaker:** (Smithfield,



Virginia) Huffaker is a two-year veteran of the KidWind program where, in the 2023 national competition in Chicago, her team won a turbine design challenge. She was

also co-captain of her high school's Green Club and maintained an impeccable academic record, all while achieving a black belt in karate and teaching self-defense techniques to members of her community. She hopes to obtain internships in offshore wind while studying engineering at Old Dominion University.

"Offshore wind's success as an industry, and the adoption of other ocean renewables alongside it, is dependent on creating a consistent pipeline of people working to build a clean energy future," said Oceantic Network CEO Liz Burdock.

"This scholarship demonstrates not only the Network and our members' support for the next wave of leaders, but the growing interest in ocean renewable energy among America's youth.

We received dozens of applications from impeccable students but, in the end, we're confident that our three winners will go on to make waves in the industry."

MORE INFO www.oceantic.org

BOEM finalizes Gulf of Maine wind research lease review

The Bureau of Ocean Energy Management (BOEM) recently announced the availability of its Final Environmental Assessment (Final EA) of an offshore wind research lease in the Gulf of Maine.

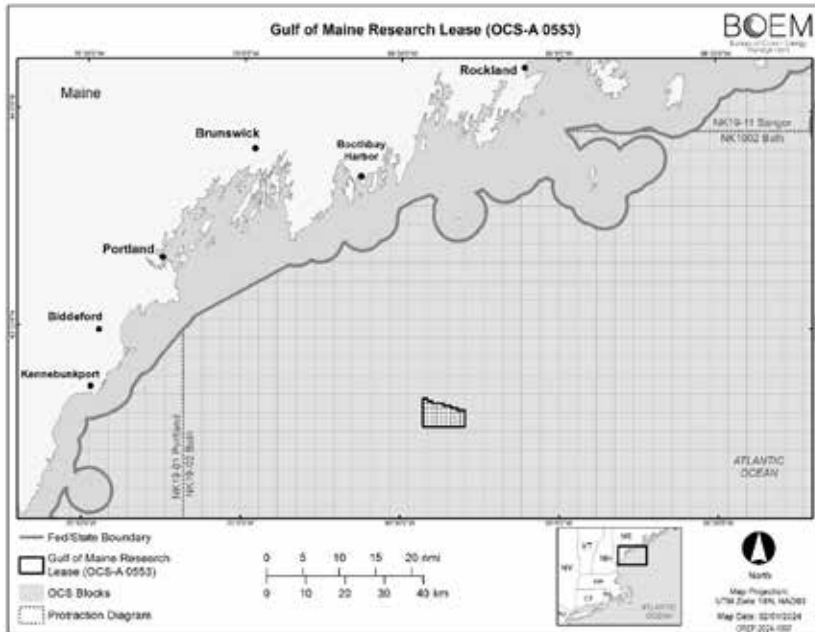
"Floating wind technology can make offshore wind a reality in the Gulf of Maine," said Elizabeth Klein, BOEM director. "BOEM will continue to work in partnership with the state of Maine as we move forward to facilitate the responsible development of offshore wind in this region, as well as the deployment of floating offshore wind technology nationwide."

In October 2021, Maine requested a research lease for the purpose of researching floating offshore wind energy technology and its deployment. The research site lies 28 nautical miles off the coast of Maine, roughly southeast of Portland and, if developed, would comprise up to 12 floating offshore wind turbines capable of generating up to 144 MW of renewable energy.

After considering alternatives described and analyzed in the Final EA, as well as comments from the public and cooperating and consulting agencies on the Draft EA, BOEM finds that the issuance of a wind energy research lease within the proposed lease area offshore Maine, and related site characterization and site assessment activities, would have no significant impact on the environment.

As a result, under the National Environmental Policy Act, BOEM is not required to prepare an Environmental Impact Statement in order to issue a wind-energy research lease offshore Maine.

Upon completion of the Final EA and finding of no significant impacts, BOEM offered the research lease to the State of Maine on May 24.



The Bureau of Ocean Energy Management recently announced the availability of its Final Environmental Assessment (Final EA) of an offshore wind research lease in the Gulf of Maine, Maine. (Courtesy: BOEM)

BOEM is exploring additional opportunities for offshore wind energy development in the U.S., including in the Gulf of Maine and the U.S. Central Atlantic coast. The Department also continues to take steps to evolve its approach to offshore wind to drive towards union-built projects and a domestic-based supply chain.

MORE INFO www.boem.gov

Wood Mackenzie appoints Zhou EVP of power, renewables



Xizhou Zhou has been appointed EVP and Head of Power and Renewables. (Courtesy: Wood Mackenzie)

Wood Mackenzie, a portfolio company of Veritas Capital, recently appointed Xizhou Zhou EVP and Head of Power and Renewables.

“Xizhou is a recognized leader in our industry and brings a

wealth of experience and expertise to Wood Mackenzie,” said Jason Liu, Wood Mackenzie CEO. “His leadership acumen, combined with his strategic foresight and ability to navigate complex energy landscapes, will undoubtedly propel our power and renewables team to new heights. We will build on his outstanding record of managing global teams, and our clients will benefit from his considerable success in creating cutting-edge data and analytics solutions related to the energy transition and renewable technologies.”

Zhou joins Wood Mackenzie from S&P Global, where he led the Global Power and Renewables division of its Commodity Insights business since the merger of IHS Markit and S&P Global. Prior to that, he spent 15 years with IHS Markit, IHS Energy, and Cambridge Energy Research Associates in Boston, Beijing, and Washington, D.C., most recently leading the firm’s Global Power & Renewables practice and Asia Pacific gas, power, and renewables business. Based in Washington, D.C., Zhou holds Bachelor of Art and Master of Environmental Management degrees, both from Yale University.

“I am thrilled to take on this leadership role at Wood Mackenzie at such a critical time in our industry,” Zhou said. “The world of power and renewables is changing rapidly with the energy transition accelerating, and Wood Mackenzie has the leading data, analytical tools, and thought leaders to help shape the future of our industry and address increasingly complex questions. I look forward to this challenge and collaborating with my colleagues at Wood Mackenzie to ensure Lens Power and the rest of our product portfolio inspire confident business decisions in a clean and sustainable energy future.”

MORE INFO www.woodmac.com

ArcVera establishes European offices, expands team



Wind industry veteran Dr. Joerg Winterfeldt has joined the ArcVera Renewables team as European Continent Manager and Senior Atmospheric Scientist. (Courtesy: ArcVera Renewables)

ArcVera Renewables, a leading global renewable energy technical consultancy, is expanding its consulting services reach by establishing European offices. Wind industry veteran Dr. Joerg Winterfeldt has joined the ArcVera Renewables team as European Continent Manager and Senior Atmospheric Scientist.

Winterfeldt will commercially develop ArcVera Renewables’ expertise in wind and solar energy, adjacent energy storage, and green power-to-X services.

“ArcVera continues to expand globally; in addition to the United States, we now have offices in Brazil, India, South Africa, and Europe,” said Greg Poulos, CEO and Principal Atmospheric Scientist, “With renewables growth

▼ Floating wind technology can make offshore wind a reality in the Gulf of Maine. BOEM will continue to work in partnership with the state of Maine as we move forward to facilitate the responsible development of offshore wind in this region, as well as the deployment of floating offshore wind technology nationwide. ▼

in solar, wind, battery storage, green hydrogen, and green Power-to-X in Europe itself, and many European renewable energy companies actively ramping up expert support in the United States and other markets we already serve globally, the timing was right to move forward.”

“I am excited to join the ArcVera expert team at this midpoint time in my career, and I am looking forward to leveraging my experience to expand

ArcVera’s European footprint,” Winterfeldt said. “Working for years with a developer, in atmospheric science, and with two top-tier wind-turbine manufacturers has given me a depth of knowledge where I can see not only how accurate energy estimation impacts project energy performance, but also how the machines are optimized to maximize the resource potential. ArcVera is a leading global technical expert in energy resources

and the machines that translate the wind resource into energy. ArcVera is a great opportunity to lend my knowledge, helping clients succeed and playing a role in the global energy transition.”

Based in the Kiel area of Germany, Winterfeldt has engaged his expertise in renewable energy since 2000 with German-based developer Projekt GmbH and wind-energy consultant Overspeed as a micro-siting expert and researched wind and cyclones in the North Atlantic in the GKSS research center.

In 2009, he teamed with General Electric as the Technical Lead - Micro-siting Optimization/Wind Resource Assessment. At GE, his most recent role was Senior Product Manager — Wind Farm Energy Guarantees. In 2022, Winterfeldt worked for Nordex as a Senior Expert — Project Optimization. ✈

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PROTECTING WIND-ENERGY WORKERS FROM CLIMATE CHANGE

It is critical for wind-energy companies to act now to confront the growing threat of heat-stress injuries to protect workers and stay competitive. (Courtesy: Shutterstock)



By combining acclimatization protocols, wearable technology, weather-based work modifications, and heat safety training, employers can minimize the risks to workers' health and productivity.

By KYLE HUBREGTSE and NICK HERNANDEZ

As the world transitions toward renewable energy to combat climate change, the wind-energy sector has seen remarkable growth in recent years. Wind farms, both onshore and offshore, are rapidly expanding to harness the power of wind and generate clean electricity. However, this surge in development is exposing a growing number of workers to the hazards of rising temperatures and heat-stress injuries exacerbated by a warming climate.

Heat-related illnesses (HRIs) pose an increasing threat to the health, safety and productivity of workers in the wind-energy industry. Outdoor workers, including those involved in the construction, operation, and maintenance of wind turbines, are at the highest risk. As global temperatures climb, the number of excessively hot days workers must endure is also on the rise. In the United States alone, outdoor workers are expected to experience a three- to four-fold increase in the number of days with a heat index above 100°F (38°C) by mid-century. This means more frequent exposure to dangerous heat conditions that can lead to a range of HRIs if not properly managed.

HEAT-STRESS SYMPTOMS

Heat stress occurs when the body is unable to adequately cool itself, resulting in rising core temperature. Early symptoms include heavy sweating, headache, dizziness, fatigue, and muscle cramps. If untreated, heat exhaustion can rapidly progress to potentially fatal heat stroke, marked by confusion, loss of consciousness, and dangerously high body temperature above 104°F (40°C). Even when not life-threatening, the physical and cognitive effects of heat stress can be debilitating for workers.

Physically, workers suffering from HRIs experience reduced strength, coordination, and work capacity. The strain of thermal stress on the cardiovascular system leads to decreased blood flow to muscles and the brain. This impairs physical performance and increases the risk of accidents and



The latest smart PPE innovations include devices worn by workers to monitor physiological indicators such as core body temperature, heart rate, and activity level. (Courtesy: Kenzen)

injuries from fatigue, dizziness, and impaired balance. Repetitive physical tasks common in wind-farm construction and maintenance become more difficult and dangerous in the heat.

Prolonged or repeated heat stress also takes a considerable toll on workers' cognitive abilities, raising the risk of errors, accidents, and injuries. Studies show heat impairs attention, memory, information retention, and complex problem-solving — all critical skills in the technical work of the wind industry. Mental fatigue and difficulty concentrating can cause workers to make mistakes, overlook safety procedures, or misjudge risks. For workers operating at heights, near high voltage, or with heavy machinery, momentary lapses from heat-dulled thinking can prove disastrous.

AFFECTING THE WORKFORCE AS A WHOLE

Left unchecked, the impacts of heat stress go beyond individual worker health and safety to affect overall workforce productivity and companies' bottom lines. Physical and mental efficiency significantly decline as temperatures rise, slowing work output. One study estimates that by 2030, the U.S. may lose nearly \$40 billion in labor productivity annually from extreme heat exposure for outdoor workers. The wind industry is not immune to such losses.

Additionally, as climate change makes heat waves more frequent and intense, companies must prepare for higher rates of absenteeism when conditions become too extreme for safe work. Replacing sidelined workers and training new hires is costly. There are also financial impacts from reduced output, project delays, and higher insurance premiums to cover heat-related workers comp claims. Cumulatively, these effects can hamper companies' ability to complete projects on time and on budget to meet the growing demand for wind energy.

Fortunately, with proper awareness, planning and interventions, HRIs are largely preventable. A key strategy is acclimatizing workers to hot conditions. Acclimatization is a physiological adaptation that occurs over days to weeks of controlled heat exposure, resulting in increased tolerance and a lower risk of heat illness. The body adapts by starting to sweat sooner and more profusely, increasing skin blood flow, and decreasing cardiovascular strain and core temperature at a given workload.

IMPLEMENTING PREVENTATIVE MEASURES

Employers should implement acclimatization protocols for new and returning workers at the start of the warm season or upon transferring from cooler climates. OSHA rec-



Wearable technology allows objective, individualized monitoring of workers' heat stress even when environmental heat measurements are within acceptable limits. (Courtesy: Kenzen)

ommends starting at 20 percent of the usual duration and intensity of work in the heat on Day 1 and gradually building up to 100 percent over one to two weeks. Regular breaks in the shade and ample hydration are also crucial. Acclimatized workers demonstrate marked improvements in work capabilities in the heat. Studies estimate that acclimatization increases productivity by 20 to 90 percent compared to an unacclimatized state.

It's important to note that acclimatization has its limits and does not provide total protection in extreme heat waves when temperatures spike suddenly. During heat waves, even stringent precautions may be inadequate to continue work safely, and it may be most prudent to halt work until conditions improve. Employers should develop heat safety plans that include monitoring weather conditions, adjusting work schedules, and setting clear weather-related work/rest thresholds.

Another promising tool for protecting workers and enhancing productivity is wearable technology. The latest smart PPE innovations include devices worn by workers to monitor physiological indicators such as core body temperature, heart rate, and activity level. This real-time data can alert workers and supervisors when heat strain approaches dangerous levels, so timely interventions can be taken. By

analyzing this data and employing predictive algorithms, wearable technology offers personalized recommendations on when to rest, hydrate, or seek shade, thus preventing HRIs before they occur.

WEARABLE MONITORING TECH

Kenzen has developed an innovative solution that provides real-time warnings to workers as they near hazardous levels of heat exposure, ultimately boosting comprehensive heat-stress management among the workforce. This continuous physiological monitoring system, worn inconspicuously on the upper arm, uses a personalized algorithm that considers diverse individual factors to accurately predict core body temperature. In addition to alerting workers through haptic vibrations emitted by the device, the system enables safety managers to monitor workers in the field via a user-friendly team dashboard. Furthermore, from a managerial standpoint, Kenzen supplies invaluable data-driven insights that can inform and shape future decision-making strategies.

Wearable technology allows objective, individualized monitoring of workers' heat stress even when environmental heat measurements are within acceptable limits. This is important because there is no one-size-fits-all heat stress threshold. Workers' susceptibility to heat varies based on fac-



If data consistently shows workers reaching heat-strain thresholds by mid-morning, supervisors can adjust schedules to shift more work to cooler early morning hours. (Courtesy: Kenzen)

tors such as age, underlying health conditions, medications, and acclimatization status. A huge advantage of wearables is the ability to track each worker's personal physiological tolerance to set individualized work/rest schedules and maximize safe productivity.

Wearables also drive productivity by enabling workers to safely work closer to their limits while still avoiding heat illness. In the past, generic guidelines based on environmental conditions alone required workers to follow overly conservative work/rest schedules, sacrificing output. Now, with continuous physiological feedback, workers can minimize breaks when not under heat strain and take necessary breaks when their personal tolerance dictates, optimizing output while working safely.

Additionally, data from wearables can reveal opportunities to improve productivity through targeted interventions. For example, if data consistently shows workers reaching heat-strain thresholds by mid-morning, supervisors can adjust schedules to shift more work to cooler early morning hours. If data indicates certain teams or work sites experience more heat stress, focused training can be delivered. By leveraging the data, companies can implement practical changes to simultaneously boost productivity and reduce heat illness risks across entire sites and organizations.

SMART BUSINESS STRATEGY

It is critical for wind-energy companies to act now to confront the growing threat of heat-stress injuries to protect workers and stay competitive. Employers who fail to take the risks seriously will find it increasingly difficult to recruit and retain skilled workers. Reports of workers falling

ill on the job erode morale, increase turnover, and deter new talent from entering the field. In contrast, employers who demonstrate leadership in heat-illness prevention can position themselves as employers of choice better able to attract and retain a thriving workforce.

Investing in heat-stress prevention is also a smart business strategy for fueling company growth. An employer's reputation for safety directly affects its ability to win contracts and investment dollars to expand.

On the global stage, renewable-energy projects are increasingly being evaluated on environmental, social, and governance (ESG) criteria that include worker welfare. Companies that score high on worker protection are more likely to secure lucrative contracts and financing to grow their operations.

The time to normalize heat-stress prevention across the wind industry is now. By combining acclimatization protocols, wearable technology, weather-based work modifications, and heat safety training, employers can minimize the risks to workers' health and productivity. Proactively implementing best practices for heat safety will help companies gain a competitive edge to continue to meet the world's growing demand for clean wind energy, even in a warming climate. When it comes to protecting workers from heat, an ounce of prevention truly yields a pound of clean-energy production. ✌

ABOUT THE AUTHORS

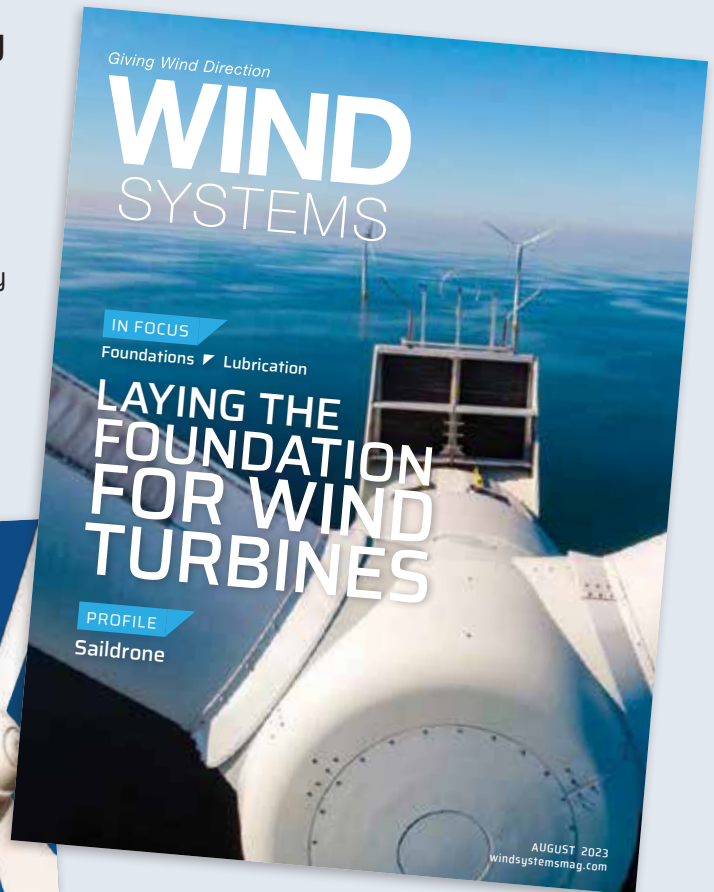
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RETHINKING WIND POWER'S TOWERS AND TURBINES



A wooden construction uses C-shaped panels, which are glued together to form a cylinder. (Courtesy: Modvion)

New materials and designs can make a leading source of renewable energy both greener and cheaper.

By TOM CASSAUWERS

At first glance, the wind-turbine tower that rises from the green landscape in the Swedish municipality of Skara looks like any other. It reaches a height of 105 meters and, at the top, supports a familiar trio of big rotating blades.

But unlike most wind-turbine towers, which are made of steel, this one is wooden. It represents the first commercial installation by Swedish engineering company Modvion — and it could point to the future of wind energy.

TOWERING WOOD

When it comes to renewable energy, wood can make wind power even greener by serving as the material for the towers.

What's more, wood can help wind turbines to become cheaper and more powerful, providing an economic incentive on top of the environmental one, according to Modvion Chief Executive Officer Otto Lundman.

“Wooden turbine towers are lighter, more modular and can be built taller than steel towers,” he said.

Modvion received EU funding to advance the goal of high-altitude wind turbines with wooden towers. The project ran from October 2020 through September 2023.

The tower of the Skara turbine emerged from the project and is made of laminated wood from Modvion's factory in Gothenburg located about 130 kilometers to the southwest.

It took about a year to build and entered into operation for Swedish power company Varberg Energi in February 2024. Denmark-based Vestas supplied the turbine.

“Building and designing towers like this requires large investments,” Lundman said. “EU funding was instrumental in allowing us to develop this technology.”

GOING FOR GROWTH

Wind energy has grown rapidly across Europe in recent years and, in 2022, met 16 percent of the EU's electricity needs. Wind also accounted for 37 percent of the electricity generated from renewable sources in the EU in 2021.

A record 17 GW of wind energy was built in Europe in 2023, according to industry association WindEurope.

Nonetheless, wind power must expand further for the EU to meet goals of cutting greenhouse-gas emissions by 55 percent in 2030 compared with 1990 levels and increasing the market share of renewables to 42.5 percent at the end of the decade from about 23 percent now.

To help achieve those targets, 30 GW of wind turbines need to be built every year between now and 2030.

The thinking in some industry circles is that new designs able to boost profitability are needed, driving scientific efforts.

“The wind-energy sector has done a great job of incrementally decreasing the cost of energy in recent decades,” said Dr. James Carroll, an associate professor at the University of

Strathclyde in the U.K. “But cost improvements in traditional turbines have been slowing down. That's why we need to look for more radical improvements.”

COUNT THE GAINS

That's where Modvion's wooden wind-turbine tower offers promise — for three notable economic reasons.

One has to do with strength. The laminated veneer lumber used by Modvion is 55 percent stronger per weight than the steel traditionally used in wind-turbine towers, according to the company.

Modvion calls its engineered wood “nature's carbon fiber.”

Another reason for optimism is weight. A wooden tower is a third lighter than a comparable steel one and, as a result, is easier to transport.

Then there's height. With the strength and transport advantages of wood, Modvion wants to build taller towers.

“The higher you go, the more wind you can get,” Lundman said.

BROADER BASES

To understand the technical challenge with towers, consider they are built like an upside-down cone: broader below and narrower on top. The taller the tower, the broader the base needs to be.

Traditionally, this is achieved by stacking steel cylinders onto each other. But above a certain tower height, it becomes virtually impossible to transport the base cylinders over roads because of their size and weight.

By contrast, a wooden construction uses C-shaped panels, which are glued together to form a cylinder. This makes the construction more modular and the shipping of parts much easier — a bit like IKEA for wind-turbine towers.

Using similar, modular steel structures would be inefficient because they would have to be bolted together, greatly increasing costs, according to Lundman.

CLIMATE RELIEF

Beyond the economic advantages of wood are the environmental ones.

Wood is better for the climate than steel. Steel production is energy-intensive and involves the burning of fossil fuels that emit greenhouse gases.

“By switching from a steel to a wooden tower, you reduce the emissions from producing the tower by 90 percent,” Lundman said.

Because forests are important storers of carbon, Modvion sources its wood from sustainably managed ones in Scandinavia. The company's towers also can be recycled after decommissioning, offering another green gain.

Following the EU funding, Modvion's priority is to scale up production.



When it comes to renewable energy, wood can make wind power even greener by serving as the material for the towers. (Courtesy: Modvion)

“Producing wood towers like this hasn’t been done before at an industrial scale,” Lundman said. “We, for example, needed to make the lamination machines ourselves. They simply didn’t exist for our purpose in these sizes.”

He said Modvion aims to have a larger volume factory up and running by 2027. The objective is to supply 10 percent of the global wind-energy market within a decade.

TURBINE TEST

Work on the next generation of wind-energy equipment involves not just the towers but also the turbines.

Another EU-funded project has reimagined what a wind turbine might look like and how it would operate.

Called XROTOR, the project has examined the feasibility of a vertical-axis turbine combined with horizontal axis secondary rotors instead of just the conventional horizontal axis. A vertical-axis turbine rotates around its tower.

“The idea goes back more than 10 years,” said William Leithead, a professor of systems and control at the University of Strathclyde. “I saw that vertical-axis wind turbines without secondary rotors just couldn’t work in an economically efficient way and started thinking about a solution.” Leithead and Carroll led XROTOR, which was due to end in April 2024 after three years and four months.

While vertical-axis turbines can be placed closer together, they have a big disadvantage: Their blades turn more slowly,

That increases the turbine drive, train size, and cost for the given energy generated, weakening the economic case for such a design. “Fundamentally, they are too costly for the energy they generate,” Leithead said.

X-SHAPED ROTOR

In response, the XROTOR researchers adapted the concept. They designed a vertical-axis turbine with an X-shaped primary rotor that has smaller, horizontal-axis turbines at the tips. The secondary rotors rotate very fast and generate the energy of the turbine. This design could combine the advantages of both vertical-axis and horizontal-axis turbines.

“You can place these turbines closer together offshore,” Leithead said. “Conventional turbines produce a wind wake, which means you can’t put them too close together or their performance will be affected.”

At present, wind farms are being pushed farther out to sea to find unfilled areas. That increases costs because turbines need to be more resistant to extreme weather, and more cables need to be laid.

If turbines could be placed closer together, more electricity could be produced nearer to shore. “The impact of this could be huge,” Leithead said. “We’re looking here at a cost saving of 20 percent compared to similar size horizontal-axis turbines.” While it has gone through simulations, the new concept has yet to be built and tested in a real-life setting, so



A wooden tower is a third lighter than a comparable steel one and, as a result, is easier to transport. (Courtesy: Modvion)

the potential benefits still need to be proven. Leithead and his colleagues are preparing to share the XROTOR results and to seek follow-up financing from private and public investors.

“It will take at least four years and probably more before we will see this concept in the real world,” Leithead said.

“It’s a radical new idea, but that’s what makes the research so fun.”

ABOUT THE AUTHOR

Tom Cassauwers is a freelance journalist from Belgium. He writes about science, technology and politics for outlets such as Trends, BBC, Al Jazeera and Horizon Magazine. Research in this article was funded by the EU’s Horizon Programme including, in the case of Modvion, via the European Innovation Council (EIC). The views of the interviewees don’t necessarily reflect those of the European Commission. This article was originally published in Horizon the EU Research and Innovation Magazine.



Wood is better for the climate than steel. Steel production is energy-intensive and involves the burning of fossil fuels that emit greenhouse gases. (Courtesy: Modvion)

IMPROVING OFFSHORE WIND SAFETY

The image features a background of several offshore wind turbines in the ocean under a blue sky. The image is split horizontally at the water surface. Above the surface, the turbines are visible with their white nacelles and yellow bases. Below the surface, the water is dark blue, and several thick black cables are seen extending from the turbines down to the seabed. The cables are secured to the seabed with green buoys or weights.

Divers have to traverse terrains as deep as 200 feet underwater to work on cables and mooring lines for offshore wind turbines. (Courtesy: Shutterstock)



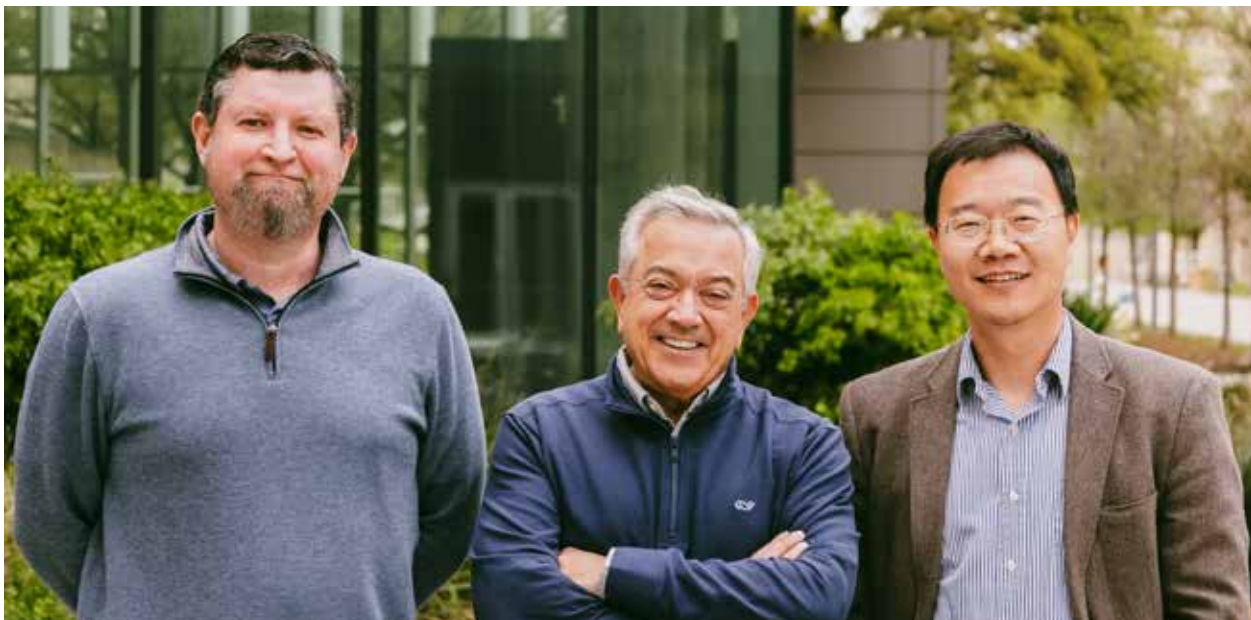
Researchers are developing technology that will provide early warnings in order to prevent divers from having to inspect underwater cables.

By KIM HORNER

Deepwater divers who monitor and maintain underwater transmission lines and cables for offshore wind turbines face hazards such as subfreezing temperatures, low visibility, jellyfish, and sharks.

A new project at The University of Texas at Dallas' Wind Energy Center, known as UTD Wind, is designed to make the divers' jobs safer through the development of remote-monitoring technology for offshore wind farms.

The \$500,000, one-year project is part of a \$2.7 million federal initiative funded through the Ocean Energy Safety Institute (OESI), a consortium of industry, national labs, nonprofits, and academic institutions, including UT Dallas, to support the development of critical safety and environmental improvements for offshore energy activities, including traditional and



From left: Mechanical engineering professors Dr. Todd Griffith, Dr. Mario Rotea, and Dr. Jie Zhang are working to develop remote-monitoring technology for offshore wind farms as part of a federal initiative funded through the Ocean Energy Safety Institute. (Courtesy: UT Dallas)

renewable energy. The OESI was organized under an agreement between the U.S. Department of Interior's Bureau of Safety and Environmental Enforcement, the U.S. Department of Energy, and the Texas A&M Engineering Experiment Station.

EXPANDING RESEARCH

The project, which began in March, expands UTD Wind research into a new area focusing on safety. Researchers will develop digital twins, or virtual models, to simulate wind turbines, and algorithms to extract information about failures from simulation data.

"We're focusing on something very important: safety. In every industry, you want zero accidents," said Dr. Mario Rotea, professor of mechanical engineering in the Erik Jonsson School of Engineering and Computer Science and principal investigator.

"We're working to develop technology to reduce human exposure to hazardous conditions in the ocean environment."

Working with Rotea are co-principal investigators Dr. Todd Griffith, professor of mechanical engineering, and Dr. Jie Zhang, associate professor of mechanical engineering. The UTD researchers are working with collaborators from NEC Laboratories America and Texas A&M University.

There are two types of offshore wind turbines: fixed platform and floating platform. Fixed platform turbines are built closer to the coast in more shallow water, while floating platform turbines can be miles from the coast, with cables and mooring lines connected to a seabed more than 100 feet below sea level. The power transmission lines connect to a

transmission center, which transfers power to the electrical grid. The water can be as deep as 200 feet. Fixed and floating wind-turbine platforms pose risks to personnel and vessels that are not seen at wind-power projects on land, according to Rotea, who is also the director of UTD Wind.

"If we can use technology to provide early warnings and prevent a diver from having to inspect an underwater cable, that would be excellent," he said.

The researchers' goal is to place sensors in accessible locations to detect damage and transmit early alarms about any problems. The technology will provide information about the conditions and improve safety for offshore wind energy personnel if they need to intervene, according to Rotea.

STUDENT OPPORTUNITIES

The project also will provide research opportunities for students. Student interest in wind technology has grown at UTD, which is home to a Wind Energy Club and a Research Experiences for Undergraduates program, funded by the National Science Foundation, that focuses on wind-energy systems. UTD Wind recently received \$1.6 million through the Consolidated Appropriations Act to establish a central headquarters for its growing wind-energy research programs.

In 2023, wind energy represented nearly 29 percent of energy generation in Texas, which has more wind turbines — 15,300 — than any other state, according to the state comptroller's office. ↵

ABOUT THE AUTHOR

Kim Horner is communications manager at the University of Texas at Dallas. This article appears courtesy of the UT Dallas.

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Giving Wind Direction

WIND
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Matthieu Boquet

Head of Wind Operations ▸ Vaisala

“Our weather-augmented wind-farm concept provides wind operators with unprecedented situational awareness and intelligence.”

▸ How does Vaisala’s “weather-augmented wind farm” approach help revolutionize wind-energy operations?

Unfortunately, too many wind farms underperform compared to their actual capacity and what was expected in the preconstruction phase due to unknowns surrounding wind and weather.

Wake losses, wind variations, and high turbulence are familiar impacts. However, changing weather conditions such as visibility, lightning, precipitation, icing, hail, humidity, and air density also significantly influence energy production, reliability, safety, and operational costs at remote wind-farm sites. While many wind-farm systems underperform and are overdesigned to account for this unpredictability, a better way exists.

Our weather-augmented wind-farm concept provides wind operators with unprecedented situational awareness and intelligence to optimize wind turbines’ performance, cost and reliability, and increases energy production. At a 300-MW wind farm, just 1 percent of additional production results in \$350,000 a year. Integrating wind Lidars, meteorological sensors, lightning detection, and advanced analytics equips project owners and operators with the real-time intelligence necessary to optimize assets, minimize downtime, mitigate costly repairs, and drive efficiency throughout the entire wind-farm life cycle.

By empowering decision makers to revolutionize energy operations and expand onshore and offshore wind farms to new frontiers, we help the wind industry meet the most pressing energy and climate challenges of our time.

▸ How does a 360-degree view of atmospheric conditions across wind farms differ from what has been done in the past?

Today, wind farms rely primarily on meteorological mast or turbine sensor data. The challenge is that turbine rotors significantly impact these instruments, creating inaccurate or missing data often not representative of the exact wind

and weather at the site without the evident ability to detect this. As an example, thanks to its advanced wind-field reconstruction, WindCube gives accurate free wind speed and direction. It enables the detection of turbine performance drift.

Integrated on every wind turbine or at the wind farm, and from wind speed and precipitation to forecasted icing conditions or lightning, 360-degree atmospheric awareness helps wind-farm owners and operators fill those gaps to better understand the weather patterns affecting wind farms. Our integrated solution combines nacelle and scanning Lidars, vertical profilers, meteorological sensors, and lightning detection to create a holistic weather-augmented wind farm.

This comprehensive wind and weather insight is used to reduce the impact of many wind and weather uncertainties and helps to increase energy production, availability, reliability, and safety.

▸ What makes up this innovative approach?

Leveraging Vaisala’s 85-plus years of environmental measurement expertise in multiple domains, our 360-degree weather approach incorporates wind Lidars, weather and environmental sensors, and data analytics into the wind-farm ecosystem, delivering previously lacking weather information.

Regardless of the geography or unique weather challenges a wind farm faces, our customizable solution set provides constant monitoring, predictive forecasting capabilities, and data intelligence tools to truly optimize wind-farm production, reliability, and predictability.

▸ What are some of the operational benefits?

The easy-to-install-and-maintain weather-augmented farm solutions seamlessly integrate wind Lidar, weather sensors, and lightning data and connect to either turbine control systems or farm SCADA systems to unlock numerous benefits for wind turbines and wind farms. Those benefits include:



Vaisala's 360-degree weather approach incorporates wind Lidars, weather and environmental sensors, and data analytics into the wind-farm ecosystem. (Courtesy: Vaisala)

✔ Detecting and forecasting wind gusts and rapid changes in wind direction allows for proactive measures to protect turbines against fatigue and extreme loads, reducing costs, and extending their performance.

✔ Conducting quick and accurate Power Performance Testing ensures compliance with expected performance and detects drifts early.

✔ Reducing wake losses by strategically operating turbines and accounting for real atmospheric conditions to maximize overall energy capture.

✔ Improving energy forecasting accuracy enables more reliable trade and power delivery.

✔ Protecting personnel and assets from potential wind gusts, lightning, low visibility, or other inclement weather-related to increase safety and optimize operation windows to minimize downtimes and damage costs.

✔ Monitoring visibility, icing, precipitations, hail, and dust particles enables optimized turbine operations strategies that maximize production during favorable conditions while protecting turbines from damages during severe conditions

✔ **Is Vaisala's solution suite scalable depending on the size and needs of a wind farm?**



Absolutely. We've designed our weather-augmented wind-farm solution set to be fully customizable based on each wind farm's unique atmospheric conditions, size, layout, and key challenges.

Our flexible combination of different types of wind Lidars, weather sensors, and digital products can be tailored to address specific issues such as wake effects, wind gusts, icing, and blade erosion or provide comprehensive monitoring across the entire site. This flexibility and scalability ensures wind operators get the right-sized environmental intelligence solution — regardless of size or whether the project is onshore, offshore, in a desert region with complex terrain, or a northern region affected by extreme cold.

► What solutions does this approach offer at the wind-farm level? At the turbine level?

At the wind-farm level, the approach deploys vertical profiling Lidars for continuous wind monitoring, scanning Lidars for wake management and ramp forecasting, and nacelle Lidars for performance optimization. It also includes precipitation and visibility sensors, ceilometers for icing conditions, lightning detection data, and integrated digital solutions.

Delivering this level of insight helps improve the operation window planning, anticipate and mitigate weather-related production losses, improve performance monitoring and production forecasting accuracy, and enhance future farm designs and production estimates through more accurate research and development. On the turbine level, our approach integrates nacelle-mounted Lidars for turbine control

and contractual PPT (Power Performance Testing), ultrasonic wind sensors, pressure/temperature/humidity sensors, visibility sensors, precipitation monitors, and lightning forecasting data into control systems. The benefits for turbines include reduced loads, increased reliability and availability, longer lifetime, minimized material costs, and improved performance.

► With the interest in offshore wind rapidly growing, can this technology help move it forward more rapidly and efficiently? How so?

Regarding offshore wind, everything is bigger — wind-farm sites, turbine rotors, project and operational costs, and revenues. Given these impacts, the harsh maritime environment, and tight offshore operating windows, any benefit is multiplied by the size of the farm, turbine energy generation potential, and the fact offshore operations are that much more expensive.

Consequently, Vaisala's weather-augmented wind-farm approach ideally supports the accelerating offshore wind sector in the U.S. and globally by providing unprecedented atmospheric monitoring that captures the full complexity of offshore sites. Whether enhancing site selection through detailed weather insights for optimal location decisions, informing safer and more efficient installation and service processes, mitigating risks, or maximizing operational performance, this level of environmental intelligence enables better project planning and execution as more wind farms are constructed in waters farther from shorelines.

► What has been the industry response to these advancements from Vaisala?

The wind-energy industry very much likes to reduce uncertainties and has responded positively to advancements across the ecosystem, recognizing the challenges in addressing underperformances across wind farms caused by inadequate wind and weather data intelligence.

By providing detailed weather and operational insights that equip operators to pinpoint issues and take corrective actions, this unique approach helps operators optimize individual turbines and entire wind farms. With detailed knowledge of wind and weather conditions enabling better forecasting and planning, operators can reduce uncertainties and increase confidence in energy outputs.

DNV, for example, highlighted in a recent white paper that nacelle Lidar-based power curves offer similar accuracy as best-in-class met mast PPTs (Power Performance Testing)—for a fraction of the cost. Operators also appreciate the cost savings from reduced maintenance and improved efficiency.

By addressing critical industrywide challenges, Vaisala helps improve project efficiency and profitability as the transition to renewable energy sources continues accelerating worldwide. ↴

MORE INFO www.vaisala.com/en

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Wind generates 78 percent of all renewable electricity output in Scotland. (Courtesy: Sarens)

CONSTRUCTION

Sarens to deliver base services for Moray West

Ocean Winds recently awarded SarensPSG with the contract to provide the intermediate delivery base services for the Moray West monopiles.

The Moray West offshore wind farm in Scotland is a key part of the country's energy transition and the path to net zero carbon emissions. The U.K. is constantly growing in new power generation capacity to maintain a secure and affordable supply. Wind power is part of the solution, and Scotland, where renewable wind capacity exceeds 11 GW, already contributes 39

percent of the U.K.'s capacity. Wind generates 78 percent of all renewable electricity output in Scotland.

"SarensPSG has unparalleled expertise, innovation, and commitment to drive positive change in the renewable energy landscape," said Steve Clark, SarensPSG managing director. "As the industry continues to evolve, SarensPSG remains at the forefront, proving to be the Sustainability Accelerator."

SarensPSG maneuvers took place in the port of Invergordon and involved the marshalling of 62 monopiles, each weighing up to 2,000 metric tons, the largest and heaviest XXL monopiles ever to be handled in the U.K., with diameters reaching up to 10 meters and a length extending to 84.7 meters. That stage was recently completed using a self-propelled modular transporter of

166 axle-lines.

The SPMT configuration comprised two sets of 80 axle-lines each, complemented by a 6-axle setup for smaller components. The selection of this equipment was determined by its flexibility, enabling transport and handling operations throughout the project. To handle the huge monopiles, the crew also devised strategic storage arrangements and sequencing methodologies to ensure efficient access to the monopiles during load-out.

Once operational, the Moray West Offshore Wind Project will contribute to the decarbonization of energy and help in creation of local employment opportunities, aligning with broader sustainability objectives.

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The first wind farm in Brittany has been completed. (Courtesy: Sarens)

▮ CONSTRUCTION

**Brittany wind farm
turbine installation
complete**

Turbine installation at the Saint-Brieuc wind farm has been completed. The first offshore wind farm project in Brittany was recently commissioned with the connection of the first wind turbines to the French grid, producing clean energy for the 610,000 inhabitants of the Côtes-d'Armor territory. This is possible thanks to the total installed capacity of 496 MW from 62 turbines, each generating 8 MW of power, which cover a surface area of 75 square kilometers 16 kilometers off the French coast, in the sector of the North Sea.

With an investment of 2.4 billion euros, it is estimated to be capable of generating enough clean energy power to 835,000 people, which will make the territory a positive energy municipality by producing more electricity than it consumes.

For another segment of the project, Sarens was also tasked with installing three tower sections of the turbine onshore on the construction tower frame (CTF). After finalizing the towers, the installation vessel Brave Tern loaded four complete towers, blades, and nacelles for the offshore turbine installation.

Brittany is prone to strong winds and high tides, which have shaped the region's landscape, economy, and way of life. The completion of the first large-scale offshore wind farm in Brittany will help harness the region's full energy potential.

MORE INFO www.sarens.com

▮ INNOVATION

**Vestas to test
sustainable
aviation fuel**

Vestas will test Sustainable Aviation Fuel (SAF) at the Baltic Eagle Wind



Vestas will test Sustainable Aviation Fuel (SAF) at the Baltic Eagle Wind Farm in the Baltic Sea. (Courtesy: Vestas)

Farm in the Baltic Sea during 2024. The pilot project entails Vestas technicians and jack-up vessel crew using helicopters partly powered by SAF to transport themselves to and from the Baltic Eagle wind farm during the construction phase of 50 offshore wind turbines.

SAF is a fuel produced from bio-waste materials such as used cooking oil or tallow. Because SAF can help reduce lifecycle greenhouse gas emissions associated with air travel, it is generally considered a more sustainable alternative to conventional jet fuel.

“This is yet another initiative through which Vestas continues to implement its sustainability strategy,” said Kieran Walsh, senior vice president and head of construction at Vestas Northern & Central Europe. “There is a significant need for more sustainable solutions during these wind farms’ construction and operation phases. The potential for using SAF in offshore operations is high and we are pleased to further exploit this potential.”

The pilot project is scheduled to take place until September 2024. Helicopter service provider HeliService will use helicopters from Leonardo S.p.a. flying on about 40 percent SAF provided by DCC & Shell Aviation Denmark A/S. A blend rate of 40 percent SAF is close to the highest possible blend rate permitted today, and it is the first time that SAF-fueled helicopters with such a high blend rate are used for an entire part during the construction phase of an offshore wind-farm operation.

CO₂ savings of about 32 percent per flight are expected compared to using a standard helicopter powered by conventional jet fuel. Vestas will assess the impact of the SAF following the end of the pilot project.

The initiative is in line with Vestas’ sustainability strategy, which includes becoming carbon neutral in Vestas’ own operations by 2030 and reducing emissions in their supply chain by 45 percent per MWh generated.

“The delivery of SAF to Roskilde

Airport, which will serve as a helicopter base during Vestas’ pilot project, marks another milestone in our efforts to support the growing demand for alternatives to conventional jet fuel,” said Sune Petersen, head of strategy and sustainability at DCC and Shell Aviation Denmark. “It also marks an initial step towards introducing SAF into the fuel mix for helicopter services — not only in Denmark but also on a European scale.”

MORE INFO www.vestas.com

INNOVATION

DNV project leads to blade standard revision

Independent energy expert and assurance provider DNV has led an initiative resulting in the revision of the

DNV-ST-0376 rotor blade standard, in response to the dynamic landscape of wind-turbine development. This update, a product of joint industry collaboration, marks a milestone in enhancing reliability and safety within the wind-energy sector.

In the realm of wind-turbine technology, heightened reliability standards are crucial to keep pace with advancements. The project, tailored to meet the evolving needs of wind-turbine developers, owners, and operators, is aimed to ensure reliability and performance.

Focusing on addressing the unique requirements of large, flexible blades for multi-megawatt turbines, the revised standard introduces comprehensive measures previously unaddressed in industry norms.

“The pace of modern wind-turbine development demands that industry standards keep pace with changing trends and technologies,” said Kim Sandgaard-Mork, Executive Vice Pres-



Independent energy expert and assurance provider DNV has led an initiative resulting in the revision of the DNV-ST-0376 rotor blade standard. (Courtesy: DNV)

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Aveva has unveiled updates to InTouch Unlimited HMI/ SCADA capabilities and pricing structure. (Courtesy: Aveva)

ident for Renewables Certification at DNV.

“Through the development of industry service documents such as service specifications, standards, and recommended practices, DNV is actively engaged in driving the renewable-energy sector forward.

This update underscores our commitment to driving innovation and quality within the wind-energy sector. By prioritizing reliability and safety, we aim to bolster industry confidence and propel the global transition towards sustainable energy solutions.”

“Not all wind-turbine blades are created equal,” said Christopher Harrison, principal engineer and service line leader for component certification, Energy Systems at DNV.

“Different design assumptions and methods, along with varying performance during validation tests, can result in differing blade performance over their lifespan.

As stakeholders in the wind-energy sector, it’s crucial to understand and mitigate these risks.”

During the project, 26 companies across the wind-turbine sector, including manufacturers, operators, and certifiers, contributed to refining and reviewing the standard. “Our goal was to provide wind-turbine stakeholders with the tools and knowledge necessary to navigate the complexities of blade development,” Harrison said.

MORE INFO www.dnv.com

► INNOVATION

Aveva updates InTouch Unlimited HMI/SCADA software

Aveva, a leader in industrial software driving digital transformation and

sustainability, recently announced updated capabilities and commercial models for its award-winning InTouch Unlimited HMI/SCADA software.

AVEVA InTouch Unlimited empowers system integrators with a comprehensive suite of HMI/SCADA technology. It is an all-inclusive licensing package available in perpetual and subscription models with unlimited tags, clients, and scalability. The InTouch Unlimited package features process historian and reporting functionality, equipping users with the ability to collect and unlock the value of data sourced at the edge and from multiple plants and systems spanning the enterprise. The modernized development tools are now available at no charge and include prebuilt templates to accelerate design productivity, as well as simplified tag and application development workflow leveraging industry standard protocols such as OPC-UA and MQTT.

As a component of the broader AVEVA Operations Control software portfolio, InTouch Unlimited can use hybrid-cloud architecture to integrate AI features such as predictive quality, throughput, and energy efficiency into traditional HMI/SCADA applications. By pairing AVEVA Operations Control with CONNECT, developers can consolidate operations data from various production lines, plants, and value chains. This provides a centralized view of operations and allows the system to scale with business growth without the need for application redevelopment.

“AVEVA InTouch Unlimited provides unprecedented value for our system integration partners,” said Doug Warren, Aveva’s senior vice-president, monitoring and control business. “This new offer, coupled with our focus on technical enablement through the Heroes HQ forum and bite sized video-based training content, makes choosing AVEVA HMI/SCADA products easier than ever.”

Aveva is headquartered in Cambridge, U.K.

MORE INFO www.aveva.com

INNOVATION

AkzoNobel opens rain erosion test facility

International®, AkzoNobel's protective coatings brand, opened a new rain erosion test facility at its hub for research and development in Felling, U.K.

The facility is fitted with sound insulation, a small laboratory, and a 1,000-liter water recycling tank, among other design elements. The rain erosion test facility will simulate real-life, harsh weather conditions to test new paint and coatings products specially designed for wind-turbine blades. At full speed, the helicopter test is capable of running at 176 meters per second, or half the speed of sound.

The test can run at full speed in under one minute, set from a computer, and can simulate weather conditions from different regions around the

world, including water flow rates and both water and air temperatures.

AkzoNobel is the first coatings company in the country to have this equipment. The 1.4 million-pound investment means that International can accelerate product development as it has the potential capacity to triple the number of tests the company can run every week. Prior to opening this facility, International outsourced this test to other companies in the U.K. and overseas twice a month.

"As one of the market leaders, AkzoNobel will now be able to more meaningfully participate in lifetime prediction discussions on protective coating systems for wind turbine blades," said Ralph Slikkerveer, R&D director for AkzoNobel's Marine, Protective, and Yacht divisions.

"Our customers can feel reassured that the International protective coatings tested at our new facility will help future-proof their blades, helping them withstand the most extreme

weather conditions of today and tomorrow," said Adam Stephenson, sales cluster manager for AkzoNobel's Marine and Protective divisions.

This is further proof that AkzoNobel is setting industry standards and connecting the dots for our customers in the wind energy sector." AkzoNobel commemorated the opening of the facility with a ribbon-cutting ceremony and guided tour attended by Gateshead Council Deputy Mayor Freda Geddes and other invited guests.

MORE INFO www.akzonobel.com

INNOVATION

Kongsberg Discovery echo sounder upgrade opens new frontiers

Ocean Science specialist Kongsberg Discovery is strengthening its indus-

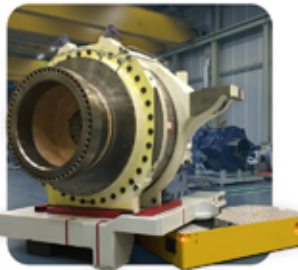
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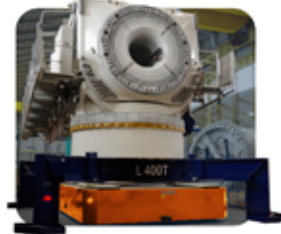
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Top view of the new EK80 wideband transducer 'ES18-11 MK2.' (Courtesy: Kongsberg Discovery)

try-leading EK80 echo-sounder product family with unprecedented wide-band low-frequency capability that will enable customers across governments, academia, and industry to gain a much more detailed picture of the ocean environment than has previously been possible, amid an increasing focus on sustainable management of the oceans.

The EK80 product family is part of Kongsberg Discovery's portfolio of monitoring and measuring tools and is used for all types of ocean research. The product family has historically been used primarily for biomass assessments, but the instruments are seeing increased adoption for other biological, physical, and chemical oceanography applications. An EK80 vessel-mounted system typically comprises six transducers operating at different sound frequency spectra, matched with transceivers, software, and planning tools. The transducers are calibrated to give highly accurate, quantitative metric values of application targets.

Kongsberg Discovery's new ES18-11

MK2 transducer widens the operational frequency spectrum of its existing ES18 split-beam transducer from 18 kHz to at least 14 to 22 kHz, increasing the resolution of the data as well as providing more information for target identification from this frequency band.

The development project also led to an improvement in transducer element design reducing the challenge with ringing, which mean that the transducer can be used for both shallow and deep-water measurements. "The ES18-11 MK2 further enhances the EK80's overall performance and brings us one step closer to uncovering the mystery of the oceans," said Lars Andersen, VP Ocean Science at Kongsberg Discovery. "It is an important innovation that we are certain will contribute to increasing knowledge of ocean biology, physics, and chemistry, in line with UN SDG 14 Life Below Water." The core application of ES18-11 MK2 remains the identification of biological targets. The 18 kHz transducer is already common

on most research vessels, but the wider bandwidth of ES18-11 MK2 can reveal the much richer biological diversity actually present. Findings can be used to fingerprint what species are present, and thus uncover components of the food chain in that area.

"Any fish stock that is commercially fished must have a management plan, and the MS18-11 MK2 will help to generate more holistic ecosystem assessments so that authorities can make better stock management decisions," Andersen said.

Understanding life in the water column is also key for environmental impact studies, for example in offshore wind-park development where EK80s already have been deployed to collect ecosystem data in Europe and the US.

The EK80 system has been and will continue to be developed over decades with input from leading marine institutes worldwide, with the overall goal of improving marine ecosystem management. Over the last few years CRIMAC, a center for research-based



“These two new tools further enhance SeaNavigator where every competitive advantage counts” says Niels Christian Kjærgaard, director EU Business Development at Weathernews Inc. (Courtesy: Weathernews Inc.)

innovation in Norway, has been the focal point of this development.

“Adding low-frequency wideband capacity is a game-changer for ocean research by providing much more details from a spectrum that holds a lot of information,” said Nils Olav Handegard, leader of CRIMAC and senior Institute of Marine Research (IMR) researcher.

Normal production of the ES18-11 MK2 has started, with scheduled deliveries from August.

MORE INFO www.kongsberg.com

➤ **INNOVATION**

Weathernews further enhances SeaNavigator platform

In line with its focus on continuous improvement of its cloud-based SeaNavigator voyage-optimization solution, Weathernews Inc recently launched two new integrated AI tools — the Berth Waiting Forecast for vessel operators and New Tonnage Finder for charterers — at a recent customer networking event in Copenhagen. Leveraging AI predictive data for enhanced voyage efficiency and emissions reduction,

the Berth Waiting Forecast enables customers to address the challenge of port delays resulting from adverse weather disrupting cargo handling.

Providing real-time ship status and congestion forecasts up to one week ahead, the tool integrates AIS data from 70,000-plus ships, weather data, as well as historical delay comparisons and trends to support users in optimizing voyage plans and adjust speed, thereby reducing fuel burn and CO2 emissions.

Waiting time is identified by analyzing vessels clustered within Weathernews’ predefined port boundaries, and calculated from average weekly values over the preceding month. The map zoom function provides a detailed visualization of vessels in the area.

The tool also provides historical reference (the count of vessels in the past month) along with a forecast of vessels that will likely be on standby in the target area in the following week — by day and time of the day. Forecasts are estimated based on historical waiting trends, past weather observations and future weather forecasts. Designed specifically for charterers to improve

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Vertical Supply Group has acquired Yates Gear. (Courtesy: Vertical Supply Group)

revenue by identifying best-performing vessels using real-time data and advanced ship-performance models, the tool leverages AIS data combined with global weather and hydrographic data and ship-performance models.

The calculation methodology uses four key parameters: good weather average speed; good weather current factor; good weather performance speed; and good weather fuel consumption. Average speed from AIS data is extracted from set periods in which conditions comply with the good weather definition, and combined with direction and speed corresponding to the current AIS position.

The current factor is then calculated based on the relative direction of the vessel's heading and current direction. This is subtracted from the

average speed to give the vessel's performance speed, while an AI model estimates fuel consumption based on individual vessel characteristics and its calculated average speed.

"Meanwhile, operational risks due to more extreme weather events will require enhanced risk profile, advanced and revised modelling and real-time notification procedures to act proactively rather than reactively – in order to secure lives and assets," West concluded.

"These two new tools further enhance SeaNavigator where every competitive advantage counts, not only in terms of minimizing logistics risk but also operational costs and environmental impact," said Niels Christian Kjærgaard, director EU Business Development at Weathernews. "They

enhance the already impressive predictive capabilities of the platform, which including the Voyage Planner and CII Simulator represents an end-to-end solution that covers all customer scenarios."

Weathernews Inc. was founded in 1986 as a service provider supporting safe maritime operations for shipping companies and is today a global leader in weather intelligence, forecasting, route optimization, emission monitoring, performance monitoring, and more. It employs about 1,100 industry professionals and dedicated staff members, all united by the company's vision to protect, care for, and use the latest technology for its customers worldwide.

In addition to a global network of offices, Weathernews also operates two



Navtor has introduced a customized approach to enhanced awareness. (Courtesy: Navtor)

private satellites and several advanced weather radars around the globe.

MORE INFO global.weathernews.com

MAINTENANCE

Vertical Supply Group purchases Yates Gear

Vertical Supply Group (VSG), a supplier and manufacturer of life safety equipment, recently announced its acquisition of Yates Gear. For more than 42 years, Yates has manufactured functional, comfortable, and durable fall protection products in the climbing, technical rescue, rope access, and tactical equipment industries. Terms of the acquisition were not disclosed.

“I have tremendous respect for Yates and what (they) have built over the years,” said Jeff Morris, CEO of Vertical Supply Group. “Their dedication to innovation and safety is second to none,

and the brand is the perfect addition to our other world-class brands such as Sterling, Notch, and Rope Logic. Their expertise in fall protection aligns perfectly with our mission to provide comprehensive safety solutions to our customers.

We look forward to offering the Yates brand and product line through our global VSG distribution channels and building on their success going forward.”

Brothers James and John Yates founded Yates Gear in 1982 as manufacturers of mountaineering and rock climbing equipment.

Their experience in big wall climbing has aided in the design and development of rescue, rigging, rope access, and tactical specific equipment that combine function, comfort, and durability.

In their 30,000-square-foot facility in Redding, California, Yates uses textiles and webbing made in the United States to produce products that are trusted around the world. “When we were looking for a partner to take over

Yates as we transition to retirement, we instantly thought of Vertical Supply Group,” said John Yates.

“We respect their passion for their brands, safety and innovation, and we are excited to see where they take Yates in the decades to come.

We would like to thank all our partners along the way, and we know you will be in good hands with VSG.”

MORE INFO www.verticalsupplygroup.com

MAINTENANCE

Navtor introduces custom approach with NavFleet

To get the vessel and fleet performance that organizations need, monitoring solutions must be tailored in accordance with individual demands. Navtor has introduced a customized approach to enhanced awareness, control, and results: user-driven passive monitoring.

The latest release of NavFleet, Navtor’s advanced fleet performance platform, creates a new monitoring reality. The customization of notifications is central, giving users the power to set parameters relevant to them.

At present, fleet management and monitoring solutions are configured to let users know when defined things happen. They receive a notification and decide whether to act upon it.

The latest NavFleet release allows users to set the parameters applicable to their business and operational requirements.

Users can set weather restrictions (spanning everything from wind speeds to tsunami warnings), or check to make sure fuels are switched at the right times to ensure compliance or be notified of route deviations or when vessel A in the fleet reaches an exact location.

Users can also limit notifications rather than be overwhelmed.

NavFleet 2.0 features main engine fuel tables for detailed vessel consump-



Nearthlab has been redefining drone solutions since 2015, pushing practical boundaries beyond industry norms. (Courtesy: Nearthlab)

tion insights, revised vessel information tabs (allowing for text updates that can be read by all shoreside users), weather play-ahead along track, an updated, new portal, and user layers (with the ability to draw layers in maps, compatible with NavStation).

More detailed port insights are also unlocked with seven-day port weather forecasts, detailed port overviews, and port lists where you can add favorites and input relevant information.

MORE INFO www.navtor.com/performance

MAINTENANCE

Nearthlab expands into contactless lightning inspection

Nearthlab, a leading provider of autonomous drone solutions, now offers inspection services for lightning protection systems (LPS). This breakthrough was made by integrating Enertrag's patented LPS measurement system into Nearthlab's cutting-edge payload

technology. Traditional LPS inspections often involve repetitive drilling to check cables beneath turbine blades, relying on rough estimates of where damage might be.

Nearthlab's non-contact inspections, however, use advanced sensors to detect changes in electromagnetic fields and pinpoint the precise location of damage. Doing so eliminates unnecessary drilling, making the process more efficient and cost-effective.

"Our roots are in wind operations and maintenance, and this expansion

underscores our commitment to enhancing turbine maintenance with cutting-edge drone technology,” said Jay Choi, co-founder and CEO. “We’re thrilled to offer equipment manufacturers and asset owners a smarter, more efficient maintenance solution.”

LPS inspections have been successfully conducted at offshore sites across Europe and Japan and are set to expand farther. Nearthlab has been redefining drone solutions since 2015, pushing practical boundaries beyond industry norms.

It seamlessly blends top-notch software and hardware to address diverse needs, from reconnaissance and surveillance to public safety and infrastructure inspection.

Nearthlab’s solutions prioritize simplicity. No learning curve — just adaptable, user-friendly designs tailored to the unique needs of various industries. Its solutions find the sweet spot in balancing hardware, software, size, and cost without having to make compromises.

Precision in data collection and a commitment to safety define Nearthlab. In high-risk scenarios such as post-disaster search and rescue missions, the company’s solutions step up to enhance operational efficiency.

MORE INFO www.nearthlab.com

▀ MANUFACTURING

Vestas unites tech, manufacturing organizations

Vestas has united the Technology organization (CTO) and Manufacturing & Global Procurement organization (COO) into one Technology and Operations organization (CTOO). The united CTOO organization will become the foundation for one enterprise-wide industrial system within Vestas and will be headed by Anders Nielsen, Vestas’ chief technology officer.

“Vestas has built a strong backlog across onshore, offshore, and service toward the end of this decade, and we



SAF-powered helicopters at the Baltic Eagle offshore wind farm in Germany. (Courtesy: Vestas)



Palfinger’s package would include life rafts and rescue boats. (Courtesy: Palfinger Marine)

are today announcing the next step in our organizational evolution to deliver on our customer commitments,” said Henrik Andersen, Vestas group president and CEO.

“The united CTOO-organization will help accelerate ramp-up and industrialization across Vestas and the industry by simplifying interfaces, collaboration and strengthening our end-to-end approach.”

The united CTOO-organization is a natural next step in Vestas’ evolution of technology and product introductions, as well as manufacturing ramp-up by simplifying interfaces within Vestas and across the value chain.

The united CTOO uses building blocks from Vestas’ global and regional operating model to minimize the impact on operations and safeguard deliveries and project execution in 2024.

The CTOO organization is expected to be fully implemented during the third quarter of 2024. With Nielsen becoming CTOO, current COO Tommy Rahbek Nielsen has decided to pursue opportunities outside of Vestas after more than 25 years.

“I’m very pleased Anders Nielsen has accepted to continue leading Vestas’ industrialization forward, and I want to thank Tommy Rahbek Nielsen for his incredible contribution to Vestas for more than 25 years,” Andersen said. “In the role as COO, Tommy was pivotal in keeping Vestas running during the pandemic, and he has done an excellent job in maturing our COO-organization to a level that enables us to take the next step for the benefit of Vestas.”

Creating the CTOO organization is only expected to affect senior management roles and not entail any restructuring at an operational level.

MORE INFO www.vestas.com

MANUFACTURING

Palfinger to provide equipment for cable laying vessel

Following previous orders to equip the state-of-the-art cable laying vessels Leonardo da Vinci and Monna Lisa, Palfinger Marine will provide deck equipment and lifesaving appliances (LSA) for another upcoming cable laying vessel built by VARD for Prysmian.

Because the vessel is the evolution of Prysmian’s previous cable layers, the package from Palfinger for the new vessel consists of a large A-frame for plough operations, an active heave-compensated lifting/towing winch, one towing winch, one quadrant/auxiliary winch, two auxiliary winches, and one towing roller. The vessel will be fitted with access equipment including one tension elevator with hatch cover, two mooring platforms, two provision platforms, and two ROV doors with L-hatches. Finally, Palfinger will supply an LSA package

encompassing two lifeboats, two fast rescue boats with davits, two life raft davits, and six fenders.

The new vessel of VARD 9 18 design — an evolutionary vessel design based on experience from the two previous vessels for Prysmian — has a length of 191 meters and breadth of 34 meters and will incorporate advanced cable installation solutions. For instance, the cutting-edge cable laying vessel will be equipped with three carousels with a total capacity above 19,000 metric tons, making it one of the highest cable loading capacity vessels in the industry. Additionally, it will feature state-of-the-art DP3 positioning and seakeeping systems.

“We are honored to be selected once again and to continue serving as a major supplier for the third cable laying vessel for Prysmian,” said Klaus Schreiber, VP Sales & Service at Palfinger Marine. “This demonstrates our position as a reliable and leading supplier of mission-critical equipment for large and advanced vessels of this kind.”

The vessel is scheduled to enter commercial operation in early 2027.

MORE INFO www.palfingermarine.com

MANUFACTURING

AWG announces Felipe Cam as chief information officer

American Wire Group (AWG) recently announced the appointment of Felipe Cam as the chief information officer (CIO). Cam is the first CIO in AWG’s history — marking a major milestone in the company’s growth. Cam will be responsible for leading and supporting the innovative digital transformation of AWG’s networks.

“We are thrilled to welcome Felipe as our new chief information officer,” said Michael Dorfman, CEO of AWG. “His extensive experience combined with his passion for innovation makes him the perfect leader to spearhead our digital transformation and take



Felipe Cam is the first CIO in AWG’s history. (Courtesy: AWG)

our business operations to the next level. We are confident that his leadership will bring significant value to our organization and our clients.”

As AWG’s CIO, Cam will oversee emerging technologies, use critical success metrics to drive IT strategies, and focus on strengthening the security and efficiency of internal technology infrastructure. Cam will also play a critical role in integrating and managing technology solutions that will elevate the customer experience and efficiency across our organization.

Cam earned his undergraduate degree from the University of Illinois and his executive MBA from the University of Miami. He brings a wealth of experience from his previous roles across logistics, manufacturing and commerce industries.

American Wire Group (AWG) is the leading material supplier of wire and cable, hardware, equipment, and accessory solutions for the utility and renewable energy markets. It maintains an extensive inventory of products utilized in the power T&D, substation, solar, wind BESS, and EV infrastructure markets in its warehouses across the country. AWG offers comprehensive services to its customers around the world, including cable management, cable engineering and design, emergency services, and more. ✈

MORE INFO www.buyawg.com

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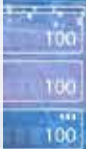
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MORE PRECISE TIMEKEEPING DEVICE SYNCHRONIZES CRITICAL UTILITY FUNCTIONS



To connect to the national grid, the electrical energy from solar panels, wind turbines, or batteries is passed through inverters or power electronic converters. (Courtesy: Shutterstock)



Utility substations require extremely precise sub-millisecond time synchronization to facilitate improved location of faults, multi-rate billing, power-flow monitoring, and event reconstruction.

By DEL WILLIAMS

Precise timekeeping is fundamental to the function of the power grid and is used in many applications to improve reliability, reduce costs, predict and prevent faults, and check operation of devices. As such, the power grid requires precise time synchronization across system-wide devices, often with sub-millisecond accuracy.

To accomplish this, extremely precise satellite clocks serve as the time source for the network time protocol, and the information is distributed to the other devices on the network. In fact, satellite clocks are standard within electric utility substations and at certain distribution line locations.

“If all of your distribution points or substations have access to a satellite clock, they share a common source for correlation,” said Nathan Irvin, product manager of networking products at NovaTech Automation, a leading U.S. provider of automation and engineering solutions for power utilities headquartered in Quakertown, Pennsylvania.

Despite being extremely accurate, utilities are continuously seeking even greater precision in timekeeping. Luckily, advancements in satellite clock design and programming can enhance accuracy. Currently, the accuracy is pushing toward achieving a margin of plus or minus 20 nanoseconds.

Utilities anticipate significant benefits from the improved accuracy, including more precise location of faults, multi-rate billing, power-flow monitoring, and event reconstruction.

HIGHLY ACCURATE SATELLITE CLOCKS

Satellite clocks work by connecting with orbiting satellites that maintain precise time using highly accurate atomic clocks. At the substation, the satellite clock receives time from the satellites in orbit. Using advanced algorithms, it then accounts for external factors to provide an accurate time.

To improve the speed of connection and accuracy, some clocks provide multi-constellation support, which provides the ability to lock into any available satellites orbiting the planet. The satellites include GPS, maintained by the U.S. but used globally; European Union’s global navigation satellite system GALILEO; China’s BEIDOU satellite navigation system; and Russia’s GLONASS global navigation satellite system.

The satellite clock serves network time protocol (NTP) to other devices on the network. These devices are typically “agnostic” and can be used as a time source for any device in the substation, regardless of brand.

Still, companies like NovaTech continue to invest in research and development to achieve even incremental improvements in clock accuracy in the sub-millisecond range.

Novatech has long served the utility industry. The company’s flagship product, Orion, is a communication and auto-

mation processor that can connect to nearly any substation device in its native protocol, perform advanced math and logic, and securely present the source or calculated data to any number of clients in their own protocol. Orion connects to IEDs such as microprocessor-based relays, meters, event recorders, and RTUs before connecting to a preexisting enterprise network or SCADA system.

“While any satellite clock can access satellites as a time source, the hardware and software within the satellite clock can make it more precise and accurate,” Irvin said. “So, in addition to our previous utility solutions, NovaTech offers timekeeping devices.”

The latest release is the Kronos Series 3. Named after Kronos, the god of time, the satellite clock provides multi-constellation support and includes several upgraded features including antenna-cable delay compensation.

“By building antenna cable-delay compensation into the algorithms for calculating time, along with multi-constellation support, we’re able to provide best in class accuracy,” Irvin said.

The Series 3 offers increased output flexibility for syncing devices with their optimal mechanisms, supporting both traditional legacy formats and the latest technologies, such as Ethernet over fiber.

The Kronos Series 3 supports PTP, NTP, and SNTP. Common legacy formats also supported include modulated and unmodulated IRIG-B over twisted pair, coax, or fiber; and PPS or PPM signals

The Kronos 3 supports parallel redundancy protocol (PRP) and the high-availability seamless redundancy (HSR) within an ethernet network. These protocols are used to implement zero-loss redundancy on wired ethernet.

“Because it is critical to maintain time and communication between the various IEDs, utilities want to build their ethernet networks in a way that if one ethernet network goes down, there is a backup that the same traffic flows across,” Irvin said.

The net results of these upgrades are more precise time with sub-millisecond accuracy.

“In the prior version of Kronos, the master clock was able to achieve 60-nanosecond maximum time deviation while locked with the satellite. For Series 3, that drops to 20 nanoseconds,” Irvin said.

Satellite clocks must also be concerned with “holdover,” which refers to the ability of a clock or timing device to maintain its accuracy and continue functioning reliably even when it temporarily loses its external reference signal due to adverse weather conditions, interference, or other factors.

During holdover, the satellite clock relies on its internal oscillator or timing mechanism to continue providing time-



Satellite clocks, standard in substations and distribution points, serve as the time source for the network time protocol (NTP), ensuring all devices share a common time reference. (Courtesy: NovaTech)

keeping information until it can reestablish a connection with the satellites. For this, Kronos Series 3 offers enhanced accuracy through an optional oven-controlled crystal oscillator for better accuracy in longer holdover situations.

An oven-controlled crystal oscillator (OCXO) is a type of crystal oscillator that maintains its frequency stability by controlling the temperature of the crystal within a temperature-controlled oven. This helps to minimize frequency drift caused by temperature variations, resulting in better accuracy over longer holdover periods.

“In holdover, TCXO has typical drift of 9ms/day, whereas OCXO has a typical drift of less than 100 μ s/day,” Irvin said. “All clocks also support out-of-bounds alarm when the time drifts more than a specified value.”

UTILITIES BENEFIT

According to Irvin, there are many applications in the power grid that can benefit from more precise timekeeping.

Multi-rate billing: Typically required accuracy: 0.5 to 1 second.

To get better utilization of the grid, power utilities often charge different prices at different times of the day. The revenue meters of utility and consumer as well as the machines and processes at the user’s site need a common time-base.

“Although this application does not require exceptional time accuracy, it can benefit utilities that implement a multi-rate billing structure,” Irvin said. “To ensure they are

charging the end customer accurately, they need to have a precise time source to know when they should switch the rates.”

Event reconstruction, sequence-of-events (SOE): Typically required accuracy: 1 to 5 ms (sub-cycle of the 50/60 Hz sine wave).

Events in the power grid need a spatial-temporal frame of reference (what happened where; what happened when) so that cause and effect can be correctly understood.

In the analysis of the large blackout of August 2003 that lasted almost 48 hours and affected 10 million people in the northeastern and midwestern United States and the Canadian province of Ontario, more time was spent ordering and manually time-tagging unsynchronized event recordings than on any other task.

“If some devices have a less accurate time source than others, then manual adjustments are required to properly reconstruct the events,” Irvin said. “Synchronizing the devices in the network with a satellite clock eliminates a lot of this type of work.”

Power-flow monitoring: Typically required accuracy: 1 to 10 μ s.

The phase component of the so-called synchrophasors can be used to estimate the power flow and the stability of a power grid. The computation of synchrophasors is only possible if all the phasor measurement units (PMUs) use a common time base.

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▼ In addition to the synchronization, it's important to accurately understand how much power is being added and when that power is added, which is where satellite clocks can play a crucial role in renewable integrations. ▼



Companies like NovaTech invest heavily in R&D to achieve incremental improvements in time keeping accuracy. (Courtesy: NovaTech)

Traveling wave-based fault location: Typically required accuracy: better than 1 μs (for a 300 m fault location accuracy).

The location of faults can be accomplished by precisely time tagging wave fronts. Faults on the power transmission system cause transients that propagate along the transmission line as waves. Each wave is a composite of several frequencies, ranging from a few kilohertz to several megahertz, having a fast-rising front and a slower decaying tail.

“Composite waves have a propagation velocity and characteristic impedance and travel near the speed of light away from the fault location toward line ends,” Irvin said. “The location of faults can be accomplished by precisely time-tagging wave fronts as they cross a known point typically in substations at line ends.”

INTEGRATION OF RENEWABLE-ENERGY RESOURCES

To connect to the national grid, the electrical energy from solar panels, wind turbines, or batteries is passed through inverters or power electronic converters. These devices convert the DC (direct current) output from the sources into AC (alternating current) suitable for transmission and distribution on the grid. In order to integrate renewable energy into the grid effectively, it must be synchronized with the existing grid frequency.

“With all these distributed renewables, it is important for them to properly tie into the existing line. They need to match the waveform frequency accurately when they are adding power to the line,” Irvin said. “In addition to the synchronization, it’s important to accurately understand how much power is being added and when that power is added, which is where satellite clocks can play a crucial role in renewable integrations.”

For utilities, precision timekeeping plays a critical role in



For utilities, precise time synchronization is vital for fault location, multi-rate billing, power-flow monitoring, and event reconstruction. (Courtesy: NovaTech)

the operation and efficiency of the power grid, emphasizing the necessity for exact time synchronization across devices to enhance reliability, minimize costs, and facilitate fault prediction and prevention.

With the use of highly accurate satellite clocks providing time synchronization with the potential to reach accuracies within plus or minus 20 nanoseconds, utilities are on the verge of achieving even greater operational precision. ↙

ABOUT THE AUTHOR

Del Williams is a technical writer based in Torrance, California. For more information on solutions for a continuously evolving power grid from NovaTech Automation, go to www.novatechautomation.com.

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