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## IN FOCUS

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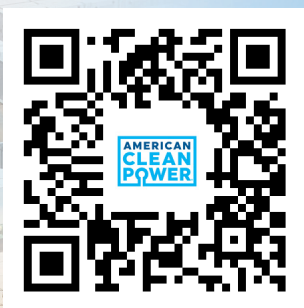
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## Wind Systems — it's easy being green

By the time you read this, we'll be at least six weeks into 2024, and as far as the future of renewable energy is concerned, I feel like it's the beginning of a brighter — and greener — future. And by green, I mean both ecologically and economically.

This year marks the fourth year of *Wind Systems*' efforts to reduce its carbon footprint by offering digital-only issues six months of the year.

Starting in 2021, *Wind Systems* began publishing six issues in a digital-only platform with the six remaining issues of the year being a print-digital issue combination. To add to our commitment to lower our carbon footprint, the six print issues are published on 10-percent recycled paper.

This, by no means, marked a change in the quality and quantity of the latest and best information about the wind-energy industry we continue to bring to you every month.

Just take a look at what this issue has to offer, and you'll see that our task to bring you interesting and informative wind-industry news has always — and is

very much still — our primary mission.

With a focus on operations and turbine maintenance, our February issue has a lot to take in.

Turbine operations can cover a wide range of expertise, from the physical nuts and bolts of an asset to the monitoring of the virtual data mined from its performance.

In our cover article from Emerson's Thomas Andersen, he addresses how turbine control retrofits and green-energy solutions platforms are transforming the way operations teams manage wind-energy generation.

In our second feature article, Randy Montgomery from ABS Group discusses how to implement a holistic approach to asset risk management, which, in today's environment, would allow companies to make high confidence asset integrity decisions, enabling them to increase the profitability and productivity of the asset base while minimizing the exposure to the risk of catastrophic events.

And get ready for a highly technical third article dealing with turbine maintenance. Dynaflo's Greg Loraine shares his expertise on water droplet erosion testing of turbine blade materials. In the article, he talks about how controlled testing throughout the turbine-blade development process is critical to selecting materials and manufacturing processes to limit leading-edge and water-droplet erosion damage and to predict their success in the field.

You'll find all that and more in this month's issue. It may be digital, but it's still 100-percent *Wind Systems*.

Stay safe and healthy out there, and, as always, thanks for reading!



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**David C. Cooper**  
President

**Teresa Cooper**  
Operations Director



# ACP appoints Anne Reynolds new offshore wind vice president

From American Clean Power

American Clean Power Association (ACP) recently announced that Anne Reynolds, a leader in the clean-energy industry, will join the organization as the new vice president, Offshore Wind, bringing a wealth of experience and a strong track record in advocacy and environmental policy.



Anne Reynolds is ACP's new vice president, Offshore Wind.

Reynolds, previously the executive director of the Alliance for Clean Energy New York (ACE NY), played a pivotal role in advancing New York's offshore wind industry and clean energy policies. Her leadership contributed to major policy wins, demonstrating her capability to drive impactful change.

ity to drive impactful change.

"We are pleased that Anne is joining ACP in this important leadership role," said Frank Macchiarola, ACP's chief policy officer. "Her combined background in government and environmental and energy advocacy makes her uniquely qualified to champion cohesive policies to expand the U.S. offshore wind industry."

In her role, Reynolds will lead ACP's efforts to advocate for and implement offshore wind strategies, working closely with member companies and state and federal policymakers to further a domestic offshore wind industry with enormous potential.

Her experience, including her role in the New York State Climate Action Council and the New York State Department of Environmental Conservation, helps bolster ACP's comprehensive understanding of environmental issues and policy development. Reynolds was also a founder of the New York Offshore Wind Alliance.



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](http://www.cleanpower.org)

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# DIRECTION

THE FUTURE OF WIND



Sun ja Wind and Transmission will employ more than 2,000 workers on-site during construction, including heavy equipment operators, electricians, laborers, and others. (Courtesy: Pattern Energy)

# Patterson Energy closes \$11 billion financing for clean-energy project

Pattern Energy Group LP, a leader in renewable energy and transmission infrastructure, recently closed an \$11 billion non-recourse financing and begun full construction of SunZia Transmission and SunZia Wind, which together is the largest clean-energy infrastructure project in U.S. history.

SunZia Transmission is a 550-mile ±525 kV high-voltage direct current (HVDC) transmission line between central New Mexico and south-central Arizona with the capacity to transport 3,000 MW of electricity across Western states. SunZia Transmission will deliver clean power generated by Pattern Energy's 3,515 MW SunZia Wind facility, which is being constructed across Torrance, Lincoln, and San Miguel counties in New Mexico.

"Our hope is this successful financing of the largest clean energy infrastructure project in American history serves as an example for other ambitious renewable infrastructure initiatives that are needed to accelerate our transition to a carbon free future," said Hunter Armistead, CEO of Pattern Energy. "We'd specifically like to thank our shareholders for their support of Pattern's efforts to deliver this critical project and meaningfully advance the world's energy transition."

This financing includes an integrated construction loan and letter of credit facility, two separate term facilities, an operating phase letter of credit facility, an innovative tax equity term loan facility and a holding company loan facility.

"SunZia represents an important step forward in the global transition to renewable energy and we are pleased to support Pattern as it works to bring this project toward completion," said Bill Rogers, managing director, global head of sustainable energies, CPP Investments. "CPP Investments' ability to provide a unique combination of flexible capital and deep expertise places us well to support projects like SunZia, which we expect will provide

attractive, risk-adjusted returns to the CPP Fund over the long term."

SunZia Wind and Transmission will employ more than 2,000 workers on-site during construction, including heavy equipment operators, electricians, laborers, and others.

**MORE INFO** [www.patternenergy.com](http://www.patternenergy.com)

## Assessment: Offshore wind at NY ports will provide many jobs

Proposed offshore wind manufacturing facilities at the Capital Region's major marine ports will bring an influx of jobs by the thousands while adding billions to the local economy, according to an economic impact assessment released recently by the Port of Albany and the Port of Coeymans.

The development and operation of proposed facilities at the two ports — Port of Albany and Port of Coeymans — would support up to 10,000 construction-related jobs, create more than 3,200 new jobs, and add \$1 billion in wages over the course of construction and first year of operations, according to the assessment. These figures include jobs and wages at the project sites, across the supply chain, and throughout the broader regional economy. Additionally, the projects would generate up to \$4 billion in total industry spending stemming from initial investment and supply chain spending over the course of construction and first year of operations.

The ports are key to positioning the Capital Region as a domestic hub for offshore wind manufacturing, with both the U.S. lacking capacity to make turbine components and supply chain issues plaguing the industry. Components made in the Capital Region will reduce America's reliance on imports while ensuring local communities will benefit from an industry that is expected to peak at 18,000 to 23,000 workers

in New York state by 2040.

The Port of Albany is building the nation's first offshore wind tower manufacturing facility; once completed, the 626,000-square-foot complex will annually produce up to 150 towers to support the turbines, which will be floated down the Hudson River.

Meanwhile, the Port of Coeymans is planning to break ground in 2024 on a production, staging, and transportation site for nacelles, which house the critical components needed to convert wind into clean energy. The Port of Coeymans has also proposed a standalone project to manufacture and transport wind-turbine blades. The projects are expected to be completed by 2026 and 2027, respectively, with production ramping up to a maximum of 60 nacelles and 180 blades per year.

Other highlights of the economic impact assessment include:

► Earnings created by new jobs at the ports will lead to increased household spending — and demand for workers in other businesses across industries that are impacted by the increased household spending. The health care, social assistance, finance and insurance, accommodation and food services, and retail sectors are projected to get the biggest boost, leading to an additional \$525 million in sales throughout construction and first year of operations, as well as 1,040 local jobs and \$61 million in annual wages for each year of operations.

► The Port of Albany facility is estimated to generate \$163 million in tax revenue during construction and its first year of operation, including \$9 million for Albany County and \$10 million for the City School District of Albany.

► The Port of Coeymans facility is estimated to generate \$232 million in tax revenue through its first year of operation, including \$12 million for the county and \$12 million for the Ravenna-Coeymans-Selkirk Central School District.



The Port of Albany facility is estimated to generate \$163 million in tax revenue during construction and its first year of operation. (Courtesy: Port of Albany)

These projects will also promote industry diversity. Hundreds of eligible, local serviced-disabled veteran-owned businesses (SDVOBs) and minority- and women-owned business enterprises (MWBs) will have the opportunity to access contracts estimated worth \$71 million during construction and \$23 million in the first year of operations of the ports' offshore wind plants.

"This shows the power ports play in commerce in New York," said Richard Hendrick, CEO of the Port of Albany. "The coordination on this is exceptionally forward thinking for both renewable energy production as well as domestic supply chain."

"Offshore wind manufacturing is an unprecedented opportunity for Albany County and validates the county's economic strategy focusing on alternative energy and green technology," said Kevin O'Connor, CEO of Advance Albany County Alliance.

"New York's ports are essential to enabling the state's bold carbon emissions reduction goals and economic development initiatives," said Rebecca

Karp, Founding Principal and CEO of Karp Strategies. "Our analysis shows that investment in offshore wind can deliver major long-term regional economic benefits. The Port of Albany and the Port of Coeymans reflect an exciting, once-in-a-generation opportunity to build new infrastructure for clean energy, support thousands of new jobs, and spark billions in economic activity,"

**MORE INFO** [www.ceg.org/wp-content/uploads/2023/12/Offshore-Wind-Economic-Impact-Analysis.pdf](http://www.ceg.org/wp-content/uploads/2023/12/Offshore-Wind-Economic-Impact-Analysis.pdf)

## Biden administration proposes Central Atlantic wind lease

The Biden administration recently announced a proposal for the offshore wind lease sale in the Central Atlantic Ocean, with the support of urged by Maryland's U.S. senators, Chris Van Hollen and Ben Cardin.

The proposed lease sale of two previously designated parcels in the Cen-

tral Atlantic Ocean is scheduled for this year. The commitment to identifying additional acreage off Maryland's shores as Wind Energy Areas (WEAs) for a subsequent lease sale in 2025 underscores the administration's responsiveness to state and local leaders, and dedication to long-term clean energy strategies.

"Offshore wind energy stands as a source of encouragement in the fight against climate change and the transition toward clean-energy alternatives," said Josh Tulkin, director of the Maryland Sierra Club. "We commend Senators Van Hollen and Cardin, and the Biden administration, for their commitment to expanding renewable energy resources and accelerating the transition to a more resilient and just energy landscape. While we are disappointed that leasing area B-1, or similar areas, were not released, we are encouraged that there is a process in place to open additional areas. Maryland cannot reach its clean energy goals without additional space being made available."

"We look forward to greater collaboration on decarbonization efforts across the Central Atlantic, and bringing about a clean energy future that is fair, equitable, and beneficial for all communities," he said.

Maryland has a goal of developing 8.5 GW of offshore wind energy by 2035, and these announced leasing areas will put the state one step closer to reaching its goal with the assurance that more areas will be leased in the near future.

**MORE INFO** [www.sierraclub.org/maryland](http://www.sierraclub.org/maryland)

## K2M releases offshore energy yield study

In the midst of an offshore wind development landscape marked by both rapid growth and a rising sense of uncertainty about supply chains and material costs, K2 Management (K2M), a project advisory and engineering consultancy for the renewable energy



Maryland has a goal of developing 8.5 GW of offshore wind energy by 2035. (Courtesy: Maryland Energy Administration)

industry, recently published “Offshore Energy Yield Predictions — Validation Report 2023,” the largest independent offshore energy yield validation study to date.

As developers expand portfolios to emerging offshore markets, K2M highlights the need to validate energy yield assessment as widely as possible across diverse geographies rather than assume the efficacy of a one-size-fits-all approach. The report underscores industry concerns regarding the universal applicability of energy yield assessment methods originally tailored for smaller onshore turbines, particularly in addressing complex interactions such as wind turbine wakes, which can differ significantly from project to project.

In a sector where confidence hinges on energy yield predictions, the report points out the necessity of ensuring the predictions are precise and backed by proven pre-construction best practice. In an industry susceptible to future shocks, consistent and precise data aims to provide all stakeholders with



K2M has released the largest independent offshore energy yield validation study to date. (Courtesy: American Clean Power Association)

a reliable benchmark for the entire development process. Contrary to more optimistic projections prevalent in the market, this approach prioritizes accuracy over inflated numbers. Looser bounds of uncertainty can create higher figures in the short term, but do not work to build long-term trust with investors or bolster a project’s financial and operational longevity, and can derail progress altogether.

“As wind energy grows, we are on a continuous learning curve: We can’t blindly rely on existing models — we need to validate and evolve our methodologies,” said Joel Manning, K2M’s manager and R&D lead — analysis services. ↴

**MORE INFO** [info.k2management.com/offshore-energy-yield-predictions-a-validation-guide](https://info.k2management.com/offshore-energy-yield-predictions-a-validation-guide)

IN FOCUS

O&M: OPERATIONS ▼ TURBINE MAINTENANCE

# ENERGIZE WIND OPERATIONS WITH MORE MODERN CONTROL





## *Turbine control retrofits and green-energy solutions platforms are transforming the way operations teams manage wind-energy generation.*

By THOMAS ANDERSEN

**A**s renewable energy gains more traction in the global economy, wind-farm owners and operators have new opportunities as what was once a niche market for energy production is now considered a critical building block of the global energy economy. Utilities of all sizes are acquiring wind assets and large wind farms to add to their enterprise — balancing their wind production with new solar and energy storage, as well as with existing hydro and fossil plants — to help meet net zero targets, meet demand by ensuring reliable electricity delivery, and maintain a stable grid.

As a result of this increased focus on the value of wind power, operations teams are being tasked with increasing output across their facilities, and even across entire fleets. As they attempt to increase efficiency and production; however, teams frequently run into roadblocks. In today's environment of skilled labor shortages, many farms are operating with limited staffing. Those skeleton crews need easy and intuitive access to asset data to make the most of their equipment, while complying with ever-changing regulations and the complexity of serving evolving grid networks.

Meeting these needs is further complicated by the aging assets wind-farm operators must depend on for day-to-day operation. Many turbines still operating today are decades old, and they are subject both to the wear and tear that is standard on aging equipment, and to the limitations of assets built years ago for a different market. Those legacy assets offer little access to the critical control logic and data operators need to improve efficiency.

Today's most successful operations teams are using a two-pronged strategy to meet these challenges — first retrofitting legacy turbine controls with modern control software and technologies — followed by implementation of green asset management platforms for improved visibility, maintenance, and control.

### **WHY RETROFIT?**

Many of the wind turbines in use around the globe have been in operation for years or even decades. As with any asset that combines electronic and mechanical parts, components, including those in the control system, begin to degrade over time. Simply replacing outdated assets is often not an op-

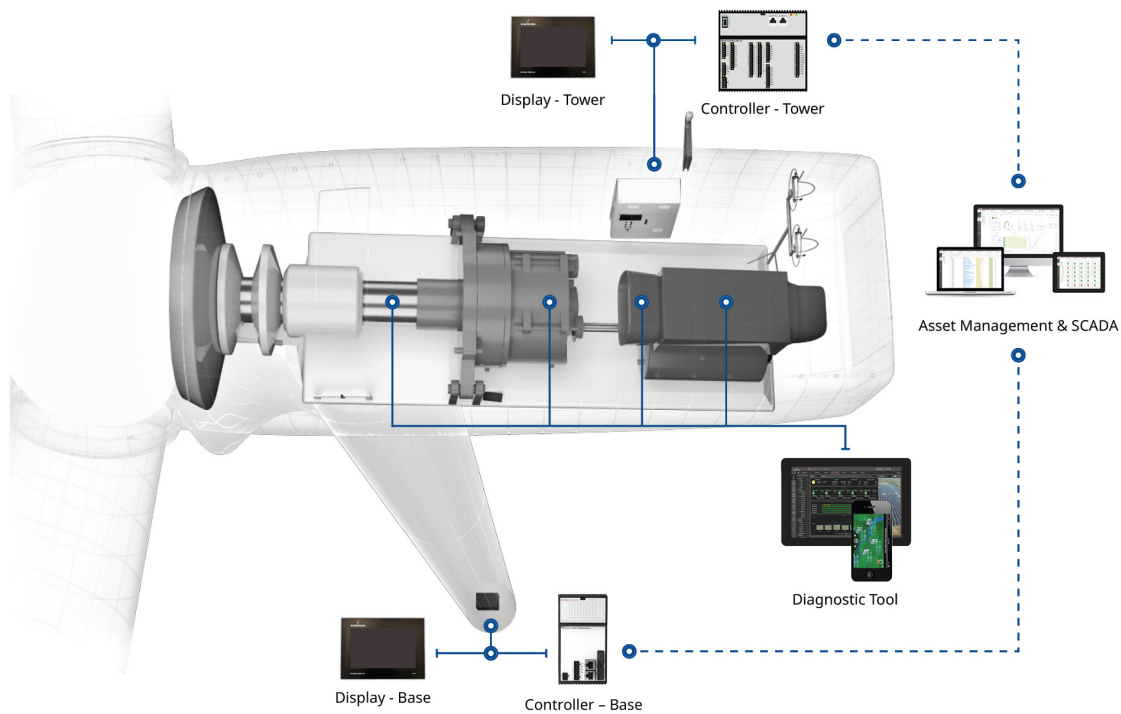


Figure 1: Comprehensive and cost-effective wind retrofit packages for older turbines, as shown in the example configuration, enable safe, quick, and easy control system upgrades that can be implemented in a few days for immediate results. (Courtesy: Emerson)

tion. New wind turbines are costly and time consuming to construct, especially when manufacturers are experiencing supply chain shortages — a common occurrence as the technology gains popularity. And even if cost and outage times are no object, in many cases, regulatory changes limit generators' capability to install new assets.

Repair is another option, but it is often more difficult than it seems. Replacement parts for legacy control systems can be complicated to specify and costly to source, if they are available at all. And even if replacement parts and service knowledge are available, many legacy control systems are incapable of handling the complex logic necessary to perform advanced control techniques and connect to modern automation platforms and smart grid systems. As a result, in some cases helping an old turbine limp along can be even more expensive than simply leaving it dormant.

Therefore, control system retrofits are often an ideal solution when repairing or replacing assets is not an option. In a retrofit project, an automation partner with a deep history of wind-generation expertise removes the old control modules from the turbine's cabinet and replaces them with a new control system that supports modern control logic. Legacy connections are left in place and connected to the modern, plug-and-play control system using custom adapters. Typically, the retrofit can be completed in a day or two (Figure 1).

## THE VALUE OF IMPROVED CONTROL

Updating a turbine's control system empowers operations teams with more access to data and improved logic for more efficient, effective automation. Typical OEM turbine control systems do not offer much access to turbine operational data. They are black boxes, where the data is only available to the manufacturer. If teams want additional data beyond what is provided through the control interface, they need to go through their OEM every time they want access.

Without data, operations teams struggle to implement effective operational changes. They are dependent on the OEM — and often, an increasingly expensive service contract — to optimize and improve service and maintenance. Retrofitting new control systems into legacy turbines gives the operations team full ownership of their data and full access to control of the turbine so they can make the operational changes necessary to drive improved performance.

## ESSENTIAL PROTECTION

One critical way in which improved control helps drive safer, more efficient, and more effective operations is in expanded automation to protect the turbine against loads. While modern turbine installations typically happen only after extensive site assessments to ensure the right turbines are used in the right locations, a decade or more ago, such



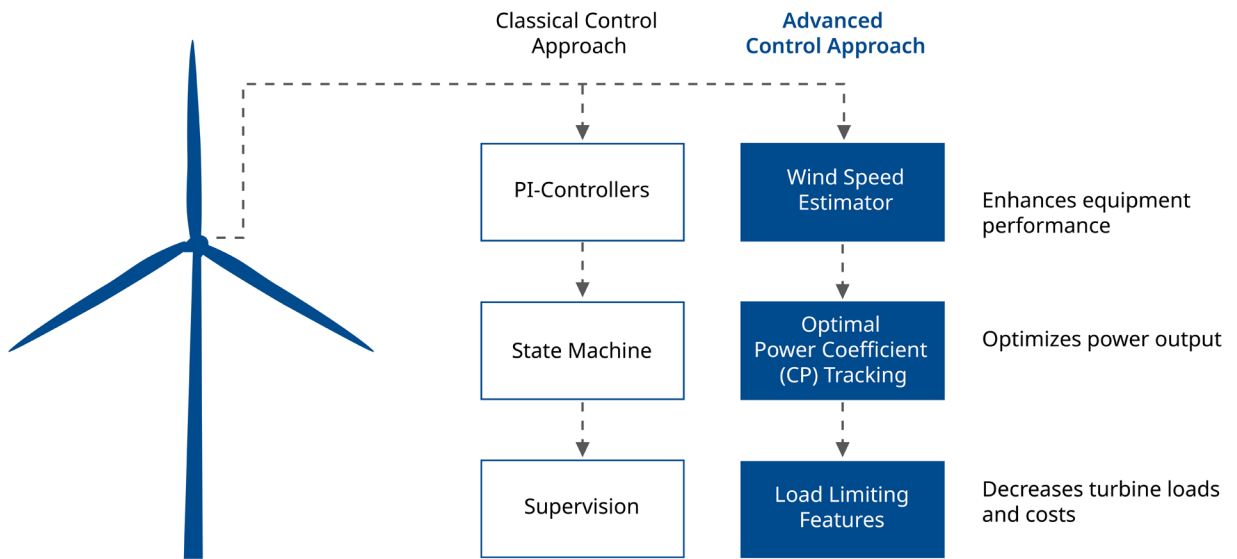


Figure 2: Advanced control strategies optimize power output, improve production, reduce loads, and minimize costs. (Courtesy: Emerson)

extensive assessments were less common. As a result, many organizations have turbines that are mismatched with the local environmental factors, such as low wind turbines on high wind sites, or turbines not designed for turbulence installed in high-turbulence areas.

The best modern turbine control systems can mitigate the effects of these site mismatches. Instead of the turbines always going into overspeed, new control systems empower operations teams to configure protective features, built into the control logic, to offset the effects of turbulence and high wind.

Moreover, the same advanced control logic can be applied to more common concerns, such as yaw and pitch misalignment. Today's advanced technologies can use control logic to automatically adjust alignment and pitch to reduce loading and oscillation.

The most advanced logic can even use load, turbine speed, and wind speed to predict how strong wind effects will be in the future, and then put limits on rotor speed to protect the turbine (Figure 2).

These small changes can have a significant impact. An 8-degree misalignment can mean a 2-percent decrease in annual production. Considering that 4 to 10 degrees of misalignment is common in a turbine, that production decrease adds up to significant lost revenue across a farm.

## IMPROVED PERFORMANCE

Modern turbine control systems also empower teams to improve their annual production by implementing more advanced control strategies than those built into OEM systems.

For example, a team with a newly retrofitted 1-MW turbine can uprate the power, enabling them to operate that turbine at 1.1 MW, adding 100 kW of production. Over time, that increase can significantly boost overall production and bring in dramatic revenue increases that quickly offset the cost of the retrofit. Alternatively, a team could choose to implement a new control strategy to boost power, moving from sub-rated to rated power to get more out of existing equipment.

## PARTNERING FOR SUCCESS

Ultimately, the benefit of control system retrofits on wind turbines comes from optimizing load and output. Teams will find that, after a retrofit, they have access to far more options than ever before, and they will need to choose the right strategy to drive the best ROI from their update. Knowing how to pick the best strategy can be critical to success.

For example, a generator selling power at a very high revenue per kilowatt-hour might not be worried about reducing life on a turbine, and, as a result, might run a strategy that increases load, while maximizing production to bring

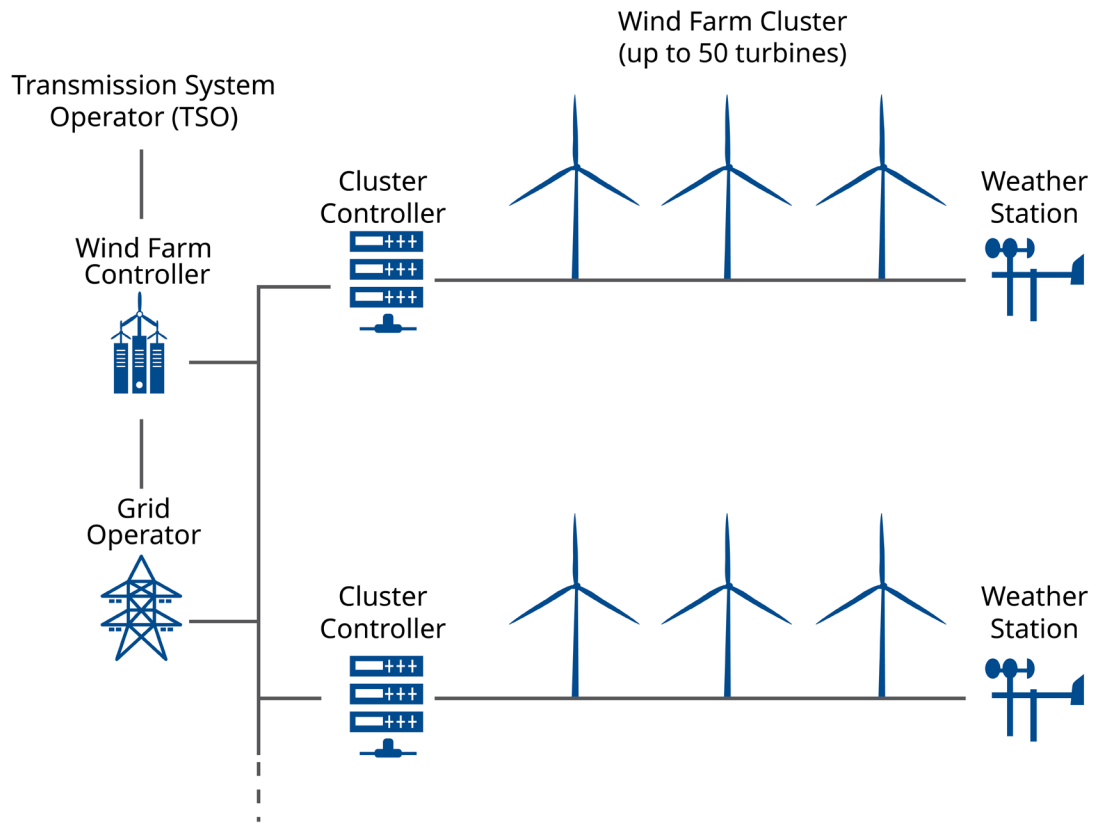


Figure 3: Location optimized intelligent wind farm control solutions that are scalable to accommodate small or large numbers of wind turbines and other power sources help ensure balanced output and grid code compliance. (Courtesy: Emerson)

in revenue as quickly as possible. But these producers are typically the minority. Most teams are looking for a good balance between load and production, and they may even need to design ways to change strategies as rates change to meet those goals. The team's automation provider can be a great resource to tap to find an optimal operating strategy — but only if they have extensive experience in power generation. A solution provider with deep power industry and wind-generation expertise can examine the organization's historical data and create estimates of equipment production and lifetime based on current strategy, and they can then make recommendations for better strategies for best ROI and long-term production.

### A SINGLE PANE OF GLASS

Another benefit of partnering with an experienced automation provider is they will have additional tools to manage an organization's assets at every level — from a single turbine to a farm, to a fleet, to a multi-site enterprise with other energy sources mixed in. The most experienced providers offer portfolios of purpose-built renewables software and automation solutions to reduce complexity through easier management of assets across the enterprise.

Using these green-energy solutions, producers can look at their complete portfolio of power-generating assets — regardless of control system — and see how they can most cost-effectively operate, maintain, and control a wide variety of assets from a single pane of glass (Figure 3). Operators no longer need to log into and navigate a wide variety of disparate OEM control systems. Instead, they control everything in the organization through a single supervisory control and data acquisition (SCADA) interface.

Experienced automation providers also offer wind-farm control solutions that operate on top of OEM or retrofitted control systems. Using a farm control system, an operations team can control all its wind turbines as a single power-producing asset. In such a configuration, they can change set-points, reserves, and more with a single communication to the grid. Wind-farm control solutions can even incorporate other energy solutions, like solar or battery storage, to help the team control all its energy sources at once.

Today's most successful organizations are choosing providers whose green-energy solutions, farm or fleet-wide control systems, SCADA and more — seamlessly integrate. With integrated solutions, teams spend less time configuring a complex web of connectivity among systems, and more time

managing and operating control for better performance across the energy value chain.

## A CHANGING PARADIGM

The benefits of an integrated green-operations platform with better control functionality are changing the way wind power generators approach future projects. Instead of the 10-20-year service agreements that used to be the standard on new turbine installations, today's providers are often pushing OEMs for 5-7-year contracts, knowing that with a control retrofit and enhanced technologies across their enterprise, they can gain control over their assets much faster to drive improved performance.

Those same teams are also planning the ways they will incorporate their new assets into their green-energy management ecosystems from the earliest stages. They are seeking out green asset management platforms that will support all new assets they bring online, and they often want to bring those assets into the system in the first days of operation to set baselines, and to track and trend performance more effectively across the lifecycle of their equipment.

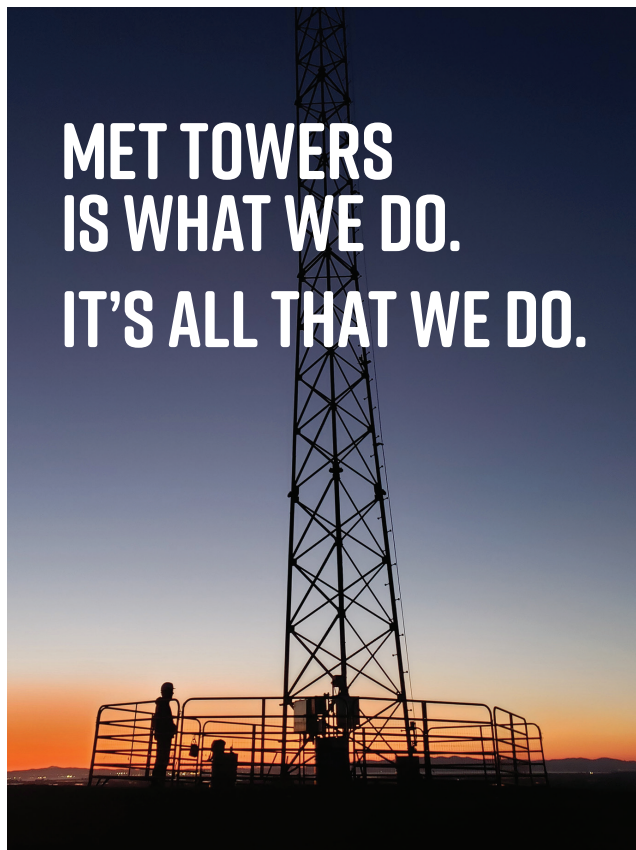
## DATA IS THE KEY

Good data is essential to safe, efficient, and effective operations. Today's wind-power operators have more options than ever to ensure they have access to that data, whether they are

doing so on legacy turbines or new installations. By planning ahead and working closely with an automation partner who understands the power and wind-generation industry, those teams can secure rapid ROI in parallel with improving their operations to help justify future projects. As the green-energy economy continues to expand, the organizations who embrace these strategies earliest will secure competitive advantage and long-term reliability across their farms, fleets, and enterprise. ↗

## ABOUT THE AUTHOR

Thomas Andersen is vice president of renewable technologies for Emerson. He has more than 30 years of renewables control and optimization experience, with a keen focus on wind generation. He began his career as an electrical technician with Mita-Teknik, a company known as a pioneer and leader in wind-generation control. In 2009, Andersen was promoted to Mita-Teknik's chief technology officer where he drove the development of state-of-the-art solutions used by wind-turbine manufacturers, OEMs, and owners and operators all over the world. In 2021, Emerson acquired Mita-Teknik, strengthening Emerson's presence in renewable energy and wind power generation. Andersen leads Emerson's expansion into the renewable sector with innovative software and technologies that increase reliability and annual energy production, while reducing operations and maintenance costs.



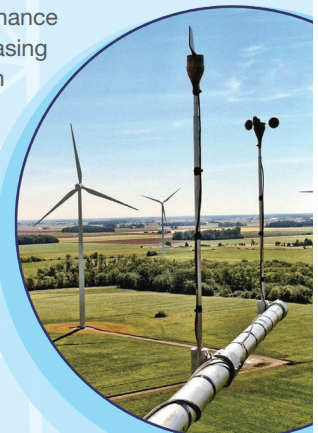
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# A HOLISTIC APPROACH TO ASSET RISK MANAGEMENT: IS IT ALL OR NOTHING?



*In today's environment, companies need to be able to also make high confidence asset integrity decisions, enabling them to increase the profitability and productivity of the asset base while minimizing the exposure to the risk of catastrophic events.*

By **RANDY MONTGOMERY**

**A**sset maintenance first hit the headlines during the late 1980s when it became a target for efficiency improvements throughout the process and chemical industries globally. Initiatives at the time focused upon traditional methods of improvement, reducing the numbers of staff and trying to work smarter with fewer resources. Despite these cuts, the pressure remained for asset managers to continue to reduce costs and increase efficiencies.

Has much changed? We believe much has improved. However, we're faced with a new era in managing risk with scope to achieve far more. The benefits of combining asset integrity and reliability programs are a major approach for today's operators of capital intensive, high-risk equipment and infrastructure including offshore wind, although the offshore wind industry is relatively new to the United States, while offshore-wind installations have been operating for more than 20 years in other parts of the world.

Based on our experience in auditing, assessing, and helping improve asset integrity and asset reliability programs, we've seen how organizations tend to develop and implement these two programs separately. The release of ISO 55000 Asset Management Standards and the increased implementation of ISO 55000 programs is now creating an industry-wide movement toward holistic asset risk management.

## **BROADENING THE SPECTRUM OF MANAGING RISK**

Asset integrity and reliability programs can help to address a broad spectrum of asset risks, including operational, environmental, and regulatory risks. There are also similarities between asset integrity and reliability programs in how effective they are at identifying safety-critical equipment and structures and asset criticality, as well as feeding into management systems and reliability business practices with the use of today's asset data and data management systems.

Typically, an organization's asset integrity program focuses on compliance with regulatory requirements, while their reliability program efforts focus on equipment and structural reliability and maintenance efficiency. With few exceptions, we have not seen organizations combine asset integrity and asset reliability programs to create a holistic asset management program.

There likely have been several motivations for maintaining and viewing these programs separately, such as:

- ▀ Desire/concern of regulator actions relative to combined programs (e.g., regulator holding an organization accountable for reliability program activities).

- ▀ Seemingly competing objectives and goals of different

organizational groups (e.g., asset integrity group, reliability group).

- ▀ Potential understanding/viewpoint that regulatory and business performance requirements need to be managed differently.

- ▀ Lack of understanding of potential efficiencies and benefits of combining these two programs.

The primary objective of both asset integrity and reliability programs is to proactively perform asset maintenance activities to reduce the likelihood of asset failures, and the overall objectives are nearly identical. One of the primary differences, however, is the type and risk level addressed by these two programs. Asset integrity programs focus on managing high-consequence events affecting safety and the environment that occur at a lower frequency, while reliability programs focus on lower-consequence events (including economic events), which often happen at a higher frequency.

While some may argue these programs are managing different risks and for some equipment or structural failures this may be true, there is likely more commonality than often first realized. For example, the high vibration of a reflux pump (discovered via a reliability vibration analysis program) may appear to be a reliability issue, but the unexpected failure of this pump could result in an over-pressurization of the tower and activation of a safety system that many would classify as a process safety management (PSM) near-miss.

Likewise, there are organizations that do not consider a leak (loss of containment) in piping as a reliability issue. In reality, leaking equipment often results in downtime (or other production impacts); therefore, leaking equipment is unreliable equipment.

This concept of an asset management program that addresses a broad spectrum of risks is not new and is provided in BS ISO 55000 series, Asset Management. One of the aspects required by this ISO standard is to identify key stakeholders and then identify each group's risk. An obvious application of this requirement would be to include all safety risks (process and occupational), environmental risks, economic risks, and other operational risks. This standard then outlines requirements for asset management programs that address all identified risks. Holistic asset management can begin by combining asset integrity and reliability programs into a single framework.

## **BLENDING ASSET INTEGRITY AND RELIABILITY PROGRAMS**

Synergies between the two approaches relate to managing the risks associated with asset degradation and failures.

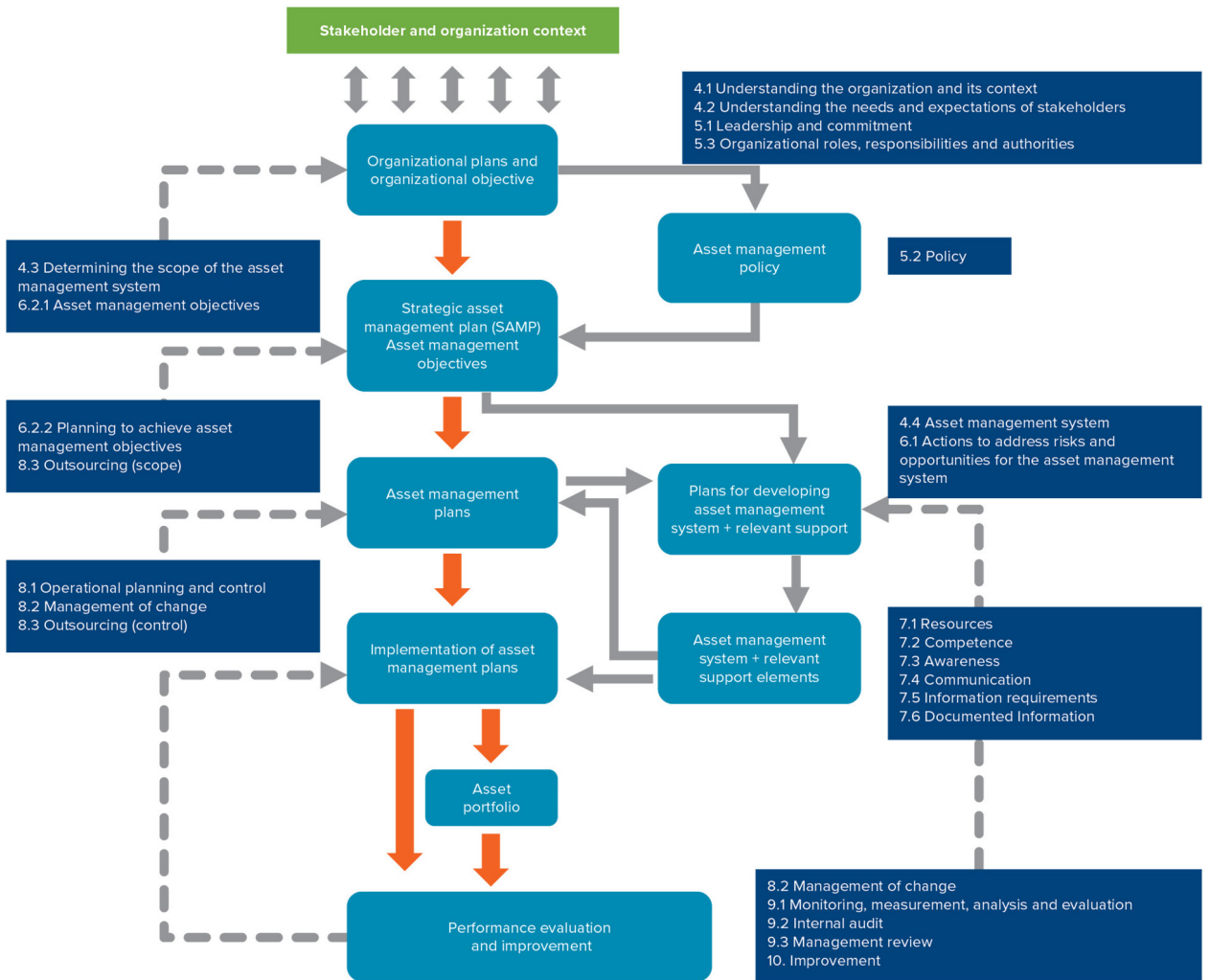


Figure 1

There are also many synergies at the program design, implementation, and execution levels of these two programs. A key aspect of both programs is the implementation of management systems (the commonly used term in the process safety world) or business processes (the commonly used term in the reliability world). Asset management systems define the overall asset management policies and objectives and the systems and processes needed (who, what, and how) to implement the asset management policies and achieve the program objectives.

ISO 55001 addresses the elements of an asset management program (the “what”) and ISO 55002 provides specifics regarding the “how” of the asset management program. Figure 1 shows the relationship between key elements of an asset management system.

Most holistic reliability programs include their management teams in core elements, such as work management, inventory management, equipment and structural main-

tenance plans (e.g., predictive and preventive maintenance plans), and computerized maintenance management system (CMMS) implementation.

So, what are the common attributes between ISO-55000, asset integrity, and Reliability program management systems?

When we look at Table 1, we can see how we can leverage and integrate activities from these three programs with a few examples of the common elements from each of these three programs.

While the strategic and conceptual similarities between Reliability and asset integrity programs are interesting, the important synergies are related to the tactical activities that influence the day-to-day implementation of these two programs.

## SYNERGIZING EXAMPLES

If we consider a few examples of potential synergy between



asset reliability and asset integrity activities – for example a process pump (in a hazardous service), it includes common reliability activities such as operator walks (visual inspection) and vibration analysis. Both of these practices are also asset integrity related activities as they help to detect and prevent loss of containment events. Another example is instrumentation and control system reliability practices, such as periodic sensor calibration and functional checks. When these practices are applied to safety-critical instruments and controls (e.g., safety instrumented systems), asset integrity requirements are incorporated.

Take the example of asset integrity practices for fixed equipment, specifically a pressure vessel. The common practices would include API-type inspections and testing such as visual inspection and pressure boundary thickness non-destructive test (NDT). Leaks in pressure vessels during operation can result in unplanned downtime (which is a reliability impact). Also, these API 500 (American Petroleum Institute) inspections and tests help predict the end-of-life for these equipment items, which allows for planning and proactive equipment replacement (which is a reliability issue). There are also common reliability practices related to managing the heat exchange fluid (e.g., cooling water) condition and/or periodic cleaning of heat-exchange surfaces. These activities can reduce the shell and tube thinning/degradation and lower the probability of a process safety event (e.g., loss of containment).

## ASSET DATA

A key area between asset integrity and reliability programs

is asset data management, where both programs require compilation, verification, and management of asset data to be effective. This data management effort involves developing a master asset list and then populating this list with relevant asset related data.

Master asset lists typically involves (1) reviewing the P&IDs and structural arrangement drawings (to identify assets), (2) compiling asset information from engineering, maintenance, operational, etc., files and records, (3) performing field walk-downs to verify the asset list and collecting missing data, (4) establishing the master asset list and data in the data management systems, and (5) organizing and associating the relevant data (e.g., drawings, original equipment manufacturer (OEM)) in the data management systems.

While the steps for developing the master asset management list for asset integrity and reliability purposes are similar, each program has slightly different data needs and sources based on equipment and structure type.

In addition to the slightly different data needs for asset integrity and reliability programs, two data management systems are typically needed to store the asset data and manage the programs. These two systems are (1) the CMMS and (2) the inspection data management system (IDMS). While these two data management systems have many similar attributes, they are used for different purposes and operate differently. The CMMS is a software application that helps maintenance organizations manage their maintenance activities in one place. The CMMS provides a platform to manage the data around your maintenance operation, including preventative, predictive, and reactive maintenance.

Having accurate and complete asset data is crucial to building a CMMS, not least of which is having the ability of the CMMS to communicate with other software systems within the organization (e.g., IDMS).

The CMMS system also serves as a repository for implementing, executing, and improving maintenance work processes (work, asset lifecycle, maintenance, repair, and operation [MRO] inventory, etc), which drive the activities and dictate how maintenance is performed.

The IDMS is used to track and manage asset condition over time to determine future inspection and testing schedules. The software system uses equipment condition assessments (e.g., thickness data) to calculate rates of degradation (e.g., corrosion) to assess the expected remaining life of the asset before failure. Additionally, the IDMS can be used to calculate the current and future risk of assets in order to optimize inspection and test plans (e.g., Risk-based Inspection [RBI]). These inspection and test plans (e.g., type of activity and due date) are sent to the CMMS for scheduling and execution planning. This transfer of information is either performed manually (e.g., plans are manually transferred from one system to another) or digitally (e.g., information is automatically transferred).

When inspection and testing results are uploaded to the IDMS, recommendations that require corrective actions to resolve equipment deficiencies are sent to the CMMS via work order for execution/tracking, and then ideally the CMMS communicates back to the IDMS when the action is completed to satisfy regulatory recording requirements.

## A CHANGE OF MINDSET — MOTIVATING THE DRIVE FOR COMBINING ASSET INTEGRITY AND RELIABILITY PROGRAMS

Organizations that do combine their asset integrity and reliability programs typically achieve tangible and intangible benefits. The tangible benefits relate to efficiencies in asset cost and programs, such as:

**1) Reducing unplanned downtime:** Implementing both asset integrity and reliability asset management plans and executing the plans as scheduled reduces both losses of containment and functional asset failures.

**2) Reducing planned downtime:** Both asset integrity and reliability asset plans include the implementation of activities related to assessing asset condition e.g., thickness monitoring (asset integrity related activity), vibration monitoring (reliability-related activity). Once implemented these types of activities reduce the need for intrusive activities (which then require assets to be offline), and help predict capital/operational expenses associated with asset replacement.

**3) Program efficiencies:** Combining the programs reduces the level of effort needed to develop and maintain program operational activities such as asset lists, maintenance work instructions, asset management plan execution, asset deficiency process, etc. The use of different work processes, data

systems, etc. to operate the asset integrity and reliability programs results in duplicated efforts.

In terms of intangible benefits, there are several organizational and cultural benefits, including:

**1) Program confidence:** A combined program provides the key organizational stakeholders (e.g., plant management, executive management) with more confidence that regulatory compliance requirements are being met; asset failure risks are being managed; and holistic asset conditions are known and being managed.

**2) Program view:** Creating a “single source” of the asset integrity and reliability provides program executors, plant management, and executive management with a single view of the asset management program.

**3) Improved program direction:** Combining the programs can reduce confusion within the organization (e.g., which system needs to be followed) and provides clear, unified expectations for the asset management program.

The bottom line is that combining the asset integrity and reliability programs can reduce the cost of asset maintenance and help reduce the perception that the asset integrity program is only a cost. Also, the intangible benefits allow organizations to move from viewing the asset integrity program as a burden to the view that both asset integrity and reliability programs make business sense.

## TOMORROW'S VIEW

In today's environment, companies need to be able to also make high confidence asset integrity decisions, enabling them to increase the profitability and productivity of the asset base while minimizing the exposure to the risk of catastrophic events. Failure to do so will allow competitors to gain a significant lead with regulators, financial markets, stakeholders, and profitability. In the future when things go wrong, questions will be asked – and in contrast to the past, it is likely there will be a requirement for greater accountability of individuals and organizations and transparency on their processes. ↴

## ABOUT THE AUTHOR

Randy Montgomery has more than 30 years of experience in reliability, maintenance, integrity management, process safety, operations and process engineering, including 13 years of industrial experience. His responsibilities at ABS Group include identifying, developing and delivering technical solutions to help Oil, Gas and Chemical industry clients preserve their right to operate and improve their return on investment. In his previous roles, Montgomery focused on assessing, designing and improving programs to confirm asset integrity and improve asset performance. He is a co-author of the Center for Chemical Process Safety's Guidelines for Effective Mechanical Integrity Programs and has co-authored several technical papers in the field of maintenance and reliability. Montgomery holds a B.S. degree in Chemical Engineering from the University of Cincinnati.



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IN FOCUS

TURBINE MAINTENANCE



# WATER DROPLET EROSION TESTING OF TURBINE BLADE MATERIALS

# *Controlled testing throughout the turbine-blade development process is critical to selecting materials and manufacturing processes to limit leading-edge and water-droplet erosion damage and to predict their success in the field.*

By GREG LORAINE

**W**ater droplet erosion (WDE) is the loss of solid material from a surface due to repeated small-scale, high-intensity pressure pulses produced by the impact of high-speed water droplets. Damage from WDE is seen in many applications including steam-turbine blades, aircraft, and missiles, as well as wind-turbine blades. Turbine blades are particularly susceptible to roughening of the surface and loss of material from the leading edge of the blades. Leading edge erosion (LEE), can substantially increase drag force and decrease lift, with as much as a 20-percent decrease in rated power of the turbine. The tips of turbine blades, where the velocity is greatest, have been reported to show LEE damage after as little as two years, and has been the cause of numerous wind installations being taken out of service before their expected end-of-service life.

New materials and manufacturing processes are being developed and applied to reduce the effects of LEE on wind turbines. But there is very little information on their ultimate performance. Accurately predicting their resistance to WDE cannot be done using only their material properties. Controlled testing throughout the development process is critical to selecting materials and manufacturing processes to limit LEE and WDE damage and to predict their success in the field. In this article, the mechanism of the damage, the details of these tests, and their strengths and limitations are discussed.

## **PREDICTING WDE RESISTANCE**

It is difficult to predict WDE resistance a priori, particularly with new materials and composites that are being developed. Resistance of a material to erosion is not a precisely definable property but is dependent on the interactions of many properties whose importance may depend on the nature, scale, and intensity of the droplet surface interactions. WDE damage to solid surfaces is caused by multiple small, but high-intensity, pressure pulses. The intensity of these impacts depends on the velocity of the droplet relative to the blade, the size of the droplets, and the rate of droplet impacts. The relative velocity of a raindrop with respect to a turbine blade will depend on the speed of the blade, the terminal velocity of the droplet, and the wind speed and direction.

The mass of the rain droplets impacting the surfaces are constrained by the size of the droplets. Typically rain droplets are 1 mm to 2 mm in diameter and rarely exceed 5 mm in diameter, thus their mass is fairly uniform. Rainfall intensity is also a consideration since it affects the rate of droplet impacts that will occur. As turbine blades increase in length and the tip velocities increase, they become more susceptible to erosion. The occurrence of WDE damage is

expected to become more prevalent as turbine blade lengths increase, and wind and storm intensities increase.

The effects of water droplet impacts are cumulative, and the rate of material loss can vary with exposure time (Figure 1). In the early stages, droplet impacts produce only small surface irregularities with little or no observable loss of material. The solid material absorbs the impact energy and deforms elastically. This incubation phase is marked by little loss of material or performance. However, with repeated erosive forces the material undergoes permanent changes. The incubation period ends with the formation of fractures in brittle materials or the plastic deformation of ductile materials. Fractures will result in intrusion of the liquid into the solid material resulting in deeper fracturing and loss of material. Plastic deformation will generate surface deformations. Ultimately, the surface asperities generated by these processes results in material removal when lateral jets produced by liquid droplet deformation impact them. The effectiveness of a protective coating or surface for delaying LEE can be related to this incubation time and can be used to directly compare different treatment methods and materials.

Once loss of material begins, the rate of erosion can increase rapidly, often increasing until it reaches a maximum, after which some materials show a decrease in erosion rates (Terminal Erosion Stage), while others will not. One theory of why some materials show a reduction in erosion rate is that the surface damage reaches an extent where liquid remains trapped in the crevices and fractures and acts to dampen further fragmentation and loss of material. In controlled testing conditions, the incubation times and maximum erosion rates can be determined from this data and are used to compare materials.

Figure 1 is an example of a sample losing mass with exposure time to water droplet impacts. For this sample, there was little loss of material for the first several minutes (incubation stage). Once the initial surface damage occurred, the observed loss of material accelerated rapidly and reached a nearly constant rate in the maximum erosion stage. As the surface became more deeply eroded, the rate of mass loss began to decrease, and the terminal stage was entered. However, it is not uncommon for materials to show a completely different erosion behavior profile.

## **METHODS OF PREDICTION**

Currently, there are two established methods for predicting the effects of WDE on materials: one from the ASTM organization based in the United States, ASTM G73 Standard Test Method for Liquid Impingement Erosion Using

Rotating Apparatus, and one from the European Organization DNV, the DNV-RP-0171 Testing of Rotor Blade Erosion Protection Systems and the method for evaluating the damage in those tests, DNV-RP-0573 Evaluation of erosion and delamination for leading edge protection systems of rotor blades. While both of these tests rotate samples at high speeds so they impact water droplets, there are important differences between them that affect how the tests are run, the results, and interpretation of the results. It is sometimes difficult to compare results between labs unless they are reported in a standardized manner, such as comparing the erosion resistance of a standard material plotted as a function of cumulative impingements in addition to the exposure time.

The ASTM G73 method can be used to test not only wind-turbine protection systems, but also metals, elastomers, plastics, composites, and ceramics. In this test, two cylindrical samples with 90-degree flat surfaces of equal mass and dimensions are mounted 180 degrees apart on a solid disc that is rotated at high speeds (Figure 2). The velocity is determined by the length of the radius and the rotation speed of the disc. Water droplets are generated by two water jets supplied by nozzles of known orifice sizes. The water droplets are assumed to be equal to the orifice diameter. The flat surfaces of the sample pieces impact the columns of water. This results in a vertical line of erosion on the faces of the samples. The sample on the left in Figure 3 is an elastomer coated metal and the right-hand image is of a metal sample.

The tests are often conducted in a chamber under partial vacuum to reduce the temperature variations due to air resistance during testing and to eliminate turbulence in the chamber that can distort the droplet shapes. In typical testing, the samples are exposed to the water droplet impingement for a set length of time, after which, the samples are removed, cleaned, weighed, and photographed. The depths of the eroded areas may also be measured. Initially, the testing times are relatively short in order to capture the incubation time when there is little weight loss or visible damage to the surface. The incubation time is one of the key results of

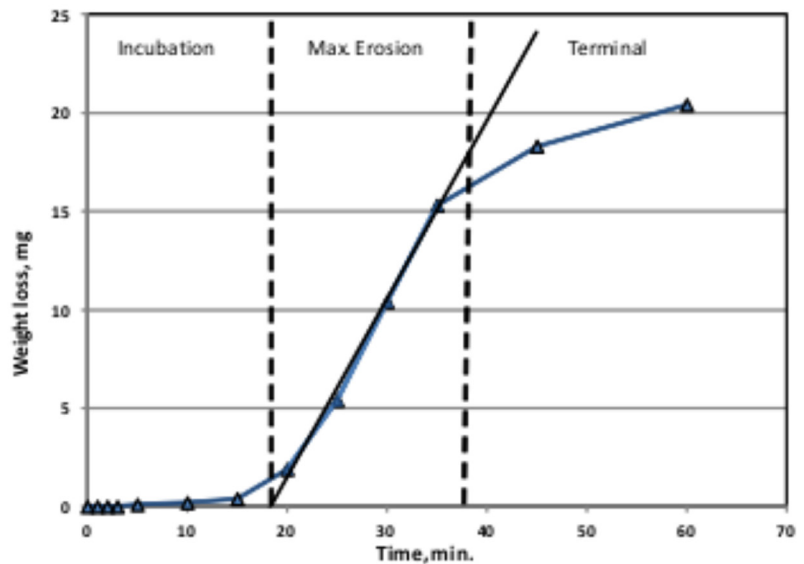


Figure 1: Example of mass loss data from an ASTM G73 test showing the three phases of erosion: incubation, maximum erosion rate, and terminal.

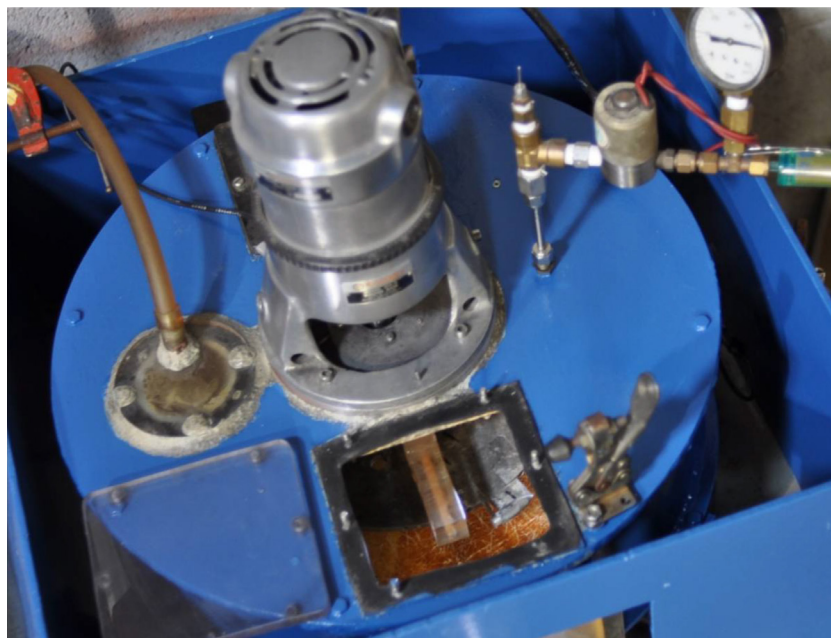


Figure 2: ASTM G73 Whirling Disc testing rig. The sample mounted on the disc and the water droplet jet can be seen in the window near the bottom of the photograph.

the test. If a protective coating such as for LEE protection of a wind-turbine blade is being investigated, the incubation time relative to that of an unprotected sample is an indication of its effectiveness. The damage to the surface will first appear as localized pitting with little loss of mass. As the number of impacts encountered by the sample increases, the surface damage becomes more severe, and the loss of material is greater. Often, the rate of erosion will reach a

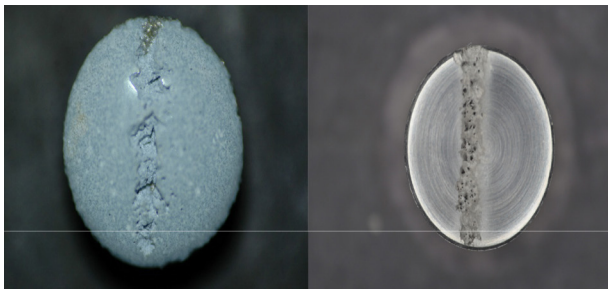


Figure 3: Examples of ASTM G73 samples after erosion testing. The left-hand image is an elastomer coated on metal; the right-hand photograph is metal sample.

maximum and then begin to decrease. After this point, the erosion rate will decrease and may reach a steady rate. However, for many materials this is not observed, and the mass loss with time plot may not show the curve seen in Figure 1.

## ADVANTAGES AND DISADVANTAGES

The advantages of using ASTM G73 testing include:

- The range of materials that can be tested (elastomers, plastics, metals, composites).
- Higher impact speeds can be obtained.
- Shorter testing times.
- Mass loss data.
- Depth data.
- Easier-to-control test parameters such as droplet size, impact speed, and erosion location.

The impact speeds and erosion intensities that can be reached are generally greater than can be achieved using a rotating arm NGV-GL-RP-0171 type test. The disadvantages are that the results may not be directly relatable to predicting wind-turbine protection performance. The ASTM G73 tests can be used to directly compare the erosion resistance of several materials under identical conditions. This infor-

mation can then be used to select or eliminate materials or manufacturing methods for further development. The NGV-GL-RP-0171 tests can then be used to compare LEE protection of different materials and construction processes.

The NGV-GL 0171 is a whirling arm distributive impact test with testing conditions that are closer to the expected conditions a wind-turbine blade would experience than the ASTM G32 test. However, it is more complex and provides limited data, namely the incubation time to LEE only. NGV-GL-0171 specifies the testing rig in detail. The testing apparatus consists of 1 to 3, 1-meter-long arms that pass through cover sprayed water droplets. The droplets can either entirely cover or partially cover the test chamber. It is often difficult to change the droplet sizes or impact speed. The samples are U-shaped 1-meter-long foil shapes with the arc facing the direction of motion. Usually, a 20-centimeter length of the sample is used as the observation region. During testing, the sample arm is not removed between test intervals. This means neither weight changes nor depth of erosion data can be collected until the completion of the test. The damage to the surface is only determined by visual inspection. When observable LEE is detected, the test is stopped.

Ideally these two tests can be used in the selection and development of turbine-protection systems. The ASTM G73 tests would be conducted to select materials and construction methods that exhibit the greatest resistance to droplet erosion damage. The NGV-GL 0171 tests are most useful for estimating the incubation time before LEE damage would be observed. Together, the two types of testing can help the design engineer predict the resistance to LEE that may be experienced during use. ✎

## ABOUT THE AUTHOR

Greg Loraine, PhD PE, is with Dynaflo, Inc. an applied research and development company. He has been involved in materials testing including ASTM G73 for 10 years.

PROFILE

K2 MANAGEMENT

# DELIVERING SUSTAINABLE ENERGY PROJECT SOLUTIONS GLOBALLY

K2 Management provides a wide range of consultancy services involving engineering, planning, project management, and due diligence for renewable-energy projects. (Courtesy: K2 Management)



*K2 Management is an independent renewable energy consultancy company with global expertise and specialist local knowledge, helping its clients to develop and operate leading energy projects with the best possible return on investment.*

By **KENNETH CARTER** ▸ Wind Systems editor

**E**ven with all the nuts and bolts and other physical properties that make up a wind farm and its assets, there still is much more behind-the-scenes involvement with getting a massive renewable-energy project to the point where it is creating power.

Consultancy services can be as vital as the actual materials that make up a wind farm, whether that farm is in the middle of Texas or jutting up out of the Atlantic.

That's where the expertise and experience of K2 Management (K2M) comes in.

"K2M, as a whole, provides a wide range of consultancy services involving engineering, planning, project management, and due diligence all across the entire value chain of mainly wind, but also solar projects," said Dr. Joel Manning, manager and R&D lead — Analysis Services with K2M. "We support clients from early development all the way through construction management and maximizing the efficiency of projects through asset management. The whole range of consultancy services are within K2M, but my particular area is in analysis services."

## DATA-LED TECHNICAL ADVICE

K2M's analysis services provide data-led technical advice, according to Manning, and its core service is pre-construction energy-yield assessment as well as operational services.

"As a department within K2M, we also provide pre-construction and operational services to both onshore and offshore wind, as well as solar projects," he said. "But that core product of pre-construction energy yield assessment is a major focus of our expertise."

For K2M's analysis services team, the ideal workflow would be to first engage clients at the very early stages of development when selecting an optimal site for a project, according to Manning.

"We might do some early analysis based on high level data, or it might be a preliminary energy yield assessment that can be done very quickly. But it allows informed site selection, and then we'll help them to design the best possible measurement campaign, which will measure the wind conditions and atmospheric conditions at the site and will eventually lead to the best, most accurate, lowest uncertainty energy yield assessment," he said.

K2M also offers what Manning calls its Meteor platform, which helps manage that wind or solar measurement data for its clients.

"As more data is measured, we can provide further energy-yield assessments with ever increasing, data-led confidence, providing a soft landing all the way to the financial decision-making time," he said. "This is when we're really

applying all of our best modeling and statistical methods to produce the lowest possible uncertainty and most accurate energy yield assessment to help value the project, minimizing the client's cost of capital when it comes to financing, and eventually building the project."

As the project progresses, K2M will also optimize the layout to help maximize the energy yield, according to Manning.

"With the energy yield assessment product, we're providing an accurate P50 prediction — a prediction where we think there's a 50/50 chance of it being above or below with the lowest possible uncertainty," he said. "Over time, we can demonstrate how accurate we are, which builds trust in our methods. The lowest possible uncertainty equates to the highest possible confidence for investors and lenders. It also equates to the best financial terms and the lowest cost of capital for the developer."

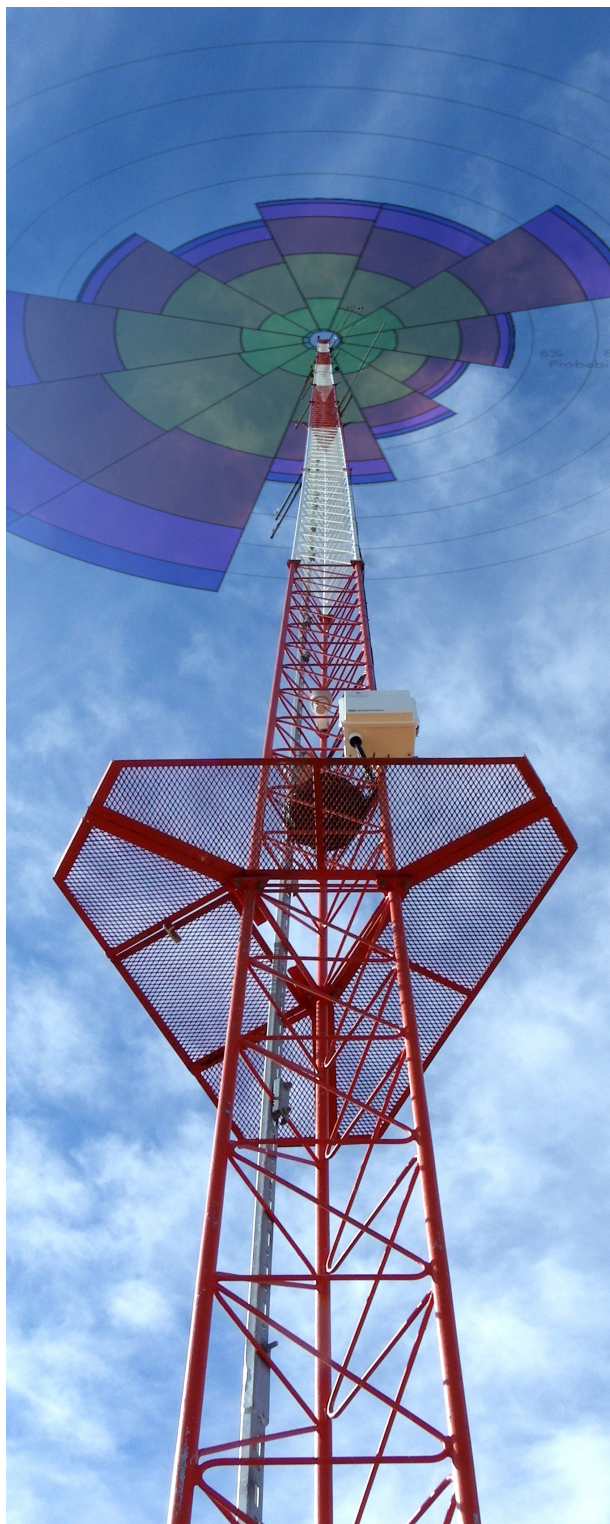
## OFFSHORE ENERGY REPORT

To that end, K2M recently released its comprehensive report, "Offshore Energy Yield Predictions — Validation Report 2023," the world's largest independent offshore energy yield validation study to date, according to Manning. The report emphasizes the importance of precise energy yield prediction and validation, citing concerns around the trend of applying overly general methodologies to offshore wind and inflating energy yield projections to secure short-term investor confidence.

"This study is something we're really proud of," he said. "It's the world's largest study of its kind. It has more data in this validation from more projects than any other offshore validation to date. The reason that's important is the more data you put into a validation, the more applicable and the more confident you can be in the conclusions. It being the world's largest means we're very confident in the conclusions. It also shows very close agreement between our predictions and what the projects finally produce. The key point for the sector as a whole is that, whilst there are currently many significant uncertainties around the development of offshore wind, prediction of energy yield isn't one of them."

The report conclusively proves that energy yield can be predicted to a high degree of precision, which provides confidence in that area of development, according to Manning.

"For K2M, being able to demonstrate our offshore energy yield prediction accuracy is very valuable," he said. "Bankability' is a big term in the energy yield assessment community, to describe whether a study can be trusted by a financial institution. However, it's a very slippery term as there's no formal definition of bankability. We feel this type



K2M recently released its comprehensive report, “Offshore Energy Yield Predictions — Validation Report 2023,” the world’s largest independent offshore energy yield validation study to date. (Courtesy: K2 Management)

of validation study is as close as you can get to a certificate of bankability.” The data from the report comes from 42 operating offshore projects, equating to about 14 GW of installed capacity spread across the whole of northern Europe, according to Manning. “We show how, across all the areas where there are currently big operating offshore wind farms, energy yield prediction can be accurate in a way that directly relates to the financial decision-making,” he said. “This is a key conclusion for the industry.”

### USING THE REPORT TO ADDRESS THE FUTURE

One of the primary goals of the report is being able to use the results to extrapolate to future projects, according to Manning.

“Whilst validation is really the only way of proving the accuracy of future predictions, the big challenge is that you can only use operational data from projects that have already been built and are operating,” he said. “This is a challenge as validation is always a little behind the technology that’s going to be applied for future projects. Currently, the offshore wind industry is still experiencing big growth in the size of turbines, the size of projects, and the density of projects, as well as expanding into other geographies. It’s always a challenge to prove that a validated method can be applied outside the envelope of the currently available data. We’re always looking to expand that validation envelope by applying more data that’s been produced by the latest technology or from a wider geographical area. We are very confident about extrapolating outside of this envelope, because we include so many physical drivers of energy yield in the modeling and statistical methods that we use to produce these predictions.”

And what has made the report a success in the eyes of K2M is that it has served to validate what the company has been doing for years, according to Manning. “It has reinforced what we’re doing; we are now even more confident in our approach,” he said. “The fundamentals of our method have not changed since the previous iteration of the validation, which we produced in 2017. In that time, the industry has seen quite a few issues, which have impacted energy yield prediction methods. I think probably most famously Orsted devalued their development portfolio some years ago due to the impact of the blockage effect, which was not commonly included in energy yield assessment prior to that. However, our methods, because they’re based on this end-to-end validation approach, were already accurate prior to that point.”

### VALIDATING K2M’S METHODS

Manning emphasized that, despite changes to the industry in the last six years, the validation has shown that K2M’s methods are reliably accurate.

“And now, producing this recent report, which contains a larger volume of data, gives us further confidence that we really are doing something that can be applied as wind-energy technology evolves,” he said. “However, we don’t take that for granted. We continually keep our eye on the technological developments and the fact that turbines and projects are





K2M has worked on hundreds of projects across all the major continents for years. (Courtesy: K2 Management)

still growing. We are constantly checking that there will not be any surprises in the future and looking for new ways to further reduce energy yield uncertainty.” The recent report has only served to give K2M more confidence in dealing with its clients and addressing any challenges they may have with their projects, according to Manning.

“We always like to see good consultancy as starting with good communication,” he said. “When a client comes to us, we need to understand the challenge that they are bringing and see what stage of development they’re at so we can provide them with the best value service that is most appropriate for their situation. But for us in analysis services, that will always be looking toward financial close and bankability. The validation report provides us, and our clients, with a very high level of confidence that we will produce the best possible accuracy at financial close, and we will help the client to reach that stage as efficiently as possible.”

## GLOBAL EXPERTISE

K2M has worked on hundreds of projects across all the major continents for years, according to Manning, as well as contributing to a large number of projects in all the major offshore markets to date.

The company supported the development of the Deutsche Bucht Wind Farm in the Southern Baltic. It has also been involved in different aspects of the development of the Dogger Bank Wind Farm, which will be the world’s largest wind farm when completed. K2M is also supporting as project manager for Pacifico in South Korea; as lender’s technical adviser for Hai Long, and as owner’s engineer on BlueFloat, both in Taiwan; and in the U.S., as owner’s engineer US Wind in Maryland, and owner’s QA representative for Dominion Energy on Coastal Virginia Offshore Wind.

With its vast history with renewable energy, it’s safe to say K2M will continue to have a hand in many more projects as net-carbon demands continue to grow across the globe, even with some recent challenges that have cropped up within the offshore sector, according to Manning.

“Looking back 10 years, a lot has changed; things were very different from what they are now,” he said. “The last few years have been challenging for the wind industry in general, and particularly for offshore wind. It’s no secret that the European OEMs have been struggling with profitability, and there have been a number of high-profile issues with large projects, particularly in the U.S. recently, as well as the auctions in the U.K.

But I think, despite that, we’re seeing that readjustment is coming to an end, and growth is starting to be back in the cards. Offshore wind continues to be a core focus and one of the largest growth areas for K2M.”

That growth is, ultimately, inevitable as long as governments continue to push their green initiatives, and Manning said K2M is in a good position to help their clients to make those projects a reality.

“K2M is extremely well-placed to support this growth,” he said. “We are able help the industry to grow efficiently and to make sure each project progresses with as little friction as possible. The offshore study that we’ve just done is one illustration of how K2M is at the forefront of technical knowledge and is able to provide practical benefits that maximize efficiency for our clients. That is one thing I don’t see changing.” ↵

**MORE INFO:** [www.k2management.com](http://www.k2management.com). For the report, go to [info.k2management.com/offshore-energy-yield-predictions-a-validation-guide](http://info.k2management.com/offshore-energy-yield-predictions-a-validation-guide).



## Jack Dougherty

Head of USV (Global) ▸ Unique Group

*“Our Unmanned Surface Vessels (USVs) play a pivotal role across various stages, contributing to the efficiency and sustainability of wind-farm projects.”*

Unique Group, global innovators in subsea technologies and engineering, recently announced the launch of two unmanned surface vessels (USVs), the Uni-Mini and Uni-Max. The USV systems have been developed entirely in-house, designed for surveying operations and engineered to meet diverse operational needs across challenging environments. *Wind Systems* recently had the opportunity to talk with Unique Group’s Global Head of Unmanned Surface Vessels, Jack Dougherty, on what these USVs could mean for the offshore wind industry and beyond.

### ▸ What is the purpose of these two new USVs?

The introduction of the Uni-Mini and Uni-Max serves a strategic purpose within our Unmanned Surface Vessels (USV) portfolio, complementing the existing Uni-Pact — a three-meter USV renowned for its autonomy, versatility, and payload capacity. While the Uni-Pact excels in various applications, including its eight-hour endurance, we recognized an emerging market niche for more compact and easily manageable solutions.

The Uni-Mini, constructed from lightweight carbon fiber, addresses this need. This smaller, two-man lift USV is designed to be transportable in the back of a pickup truck, making it an ideal solution for infrequent users or scenarios where a full-scale industrial USV may be impractical. Responding to customer requests for dual payloads and extended endurance, the Uni-Mini stands as a versatile tool. It’s for customers who don’t consistently need a full industrial strength, industrial size surface vessel USV.

For example, let’s say you are in New Orleans or you’re down on the Gulf Coast and a hurricane comes in. You have got a small marina or anchorage there, and you need to make sure that it’s clear before you allow other vessels to transit in and out. To help in this situation, you can deploy the Uni-Mini, and it can perform a quick multi-beam survey and based on the results, you will be good to go to bring the boats in before the hurricane.

At the other end of the spectrum, the Uni-Max emerges as a substantial addition to our fleet. Boasting a 5-meter by 2.2-meter frame, the Uni-Max provides a more robust platform capable of handling dual payloads. Its hybrid powertrain, incorporating a generator for extended range, facilitates an impressive endurance exceeding 96 hours. This larger and more powerful USV is positioned as a dependable solution for comprehensive and prolonged missions, demonstrating a commitment to meeting the diverse needs of our clientele across a spectrum of industrial and environmental applications.

### ▸ Was that part of why you found it necessary to develop these new USVs, the size differentials mainly, or was something else involved as well?

We developed these new USVs after identifying a market niche, hence we provide our clients with options suitable for their diverse applications as well as project budgets. At Unique Group, we formulate a price point where clients can either rent or buy the solution they need.

When it comes to the Uni-Mini, it’s a very low barrier to entry even with its carbon-fiber body, it’s a relatively inexpensive platform for the capability it possesses. Then there’s a general step-up to the larger Uni-Pact and then all the way out to the Uni-Max.

### ▸ What makes the USVs unique?

USVs are cost-efficient, robust, and reliable platforms that can operate in multiple environments from shallow water to offshore. With Uni-Fleet, we try to keep it down cost-wise, not just in the platform itself but also in the cost for training. The three vessels utilize a common autopilot system. If you’re proficient in operating the Uni-Mini effectively, you can also operate the Uni-Max.

The payload operations function independently and are not integrated into the overall system, making it straightforward for operations.



The introduction of the Uni-Mini and Uni-Max serves a strategic purpose within Unique Group's Unmanned Surface Vessels (USV) portfolio. (Courtesy: Unique Group)

### ► How can the USVs be used in the development of offshore wind?

Our Unmanned Surface Vessels (USVs) play a pivotal role across various stages, contributing to the efficiency and sustainability of wind-farm projects. Commencing from the initial phases of pre-construction, these USVs are instrumental in conducting site surveys and mapping exercises. This ensures meticulous assessment of the seabed's capacity to support the prolonged weight and operational demands of wind turbines over the course of decades.

Beyond site assessment, USVs are adept at environmental monitoring, offering a versatile platform equipped with specialized sensors. This capability extends to maintenance and inspection tasks, as well as providing security and surveillance for the wind farm. Remarkably, a single USV can seamlessly transition between these diverse roles, from ensuring the security of the site to employing sensors for environmental monitoring and utilizing cameras for visual inspections of turbine components.

For larger USVs, their utility extends further to the transportation of materials and personnel essential for the

offshore platforms. These autonomous vessels are adept at efficiently ferrying personnel and required materials to and from the platforms, thereby facilitating the smooth functioning and sustenance of wind farms. This comprehensive range of functionalities underscores the adaptability and effectiveness of USVs in addressing the multifaceted needs of the offshore wind industry, contributing significantly to the overall success of wind energy projects.

### ► Why the need for the two separate classifications?

The differentiation between the Uni-Mini and Uni-Pact classifications is driven by distinct operational requirements. The Uni-Mini, with its compact 1.6-meter size, excels in navigating tight spaces and shallow waters, providing an excellent solution for tasks such as dredging and shoreline assessments. Its role extends to leading manned vessels in reconnaissance during storms, ensuring safe navigation. In contrast, the larger Uni-Pact, with enhanced payload capacity, addresses comprehensive survey and operational needs. This strategic classification allows us to offer specialized solutions tailored to specific tasks and environments.

## ▀ What's been the market response so far?

The market response to our recent developments has been highly positive. We already had an established name in the USV market because Unique Group doesn't just sell, but we also rent. It's quite a big market for us in the energy sector. We have already been successful with the Uni-Pact, and now we are providing two more solutions to problems that customers genuinely had. The decision to offer both a smaller and a larger USV was a strategic response to specific customer demands of wanting higher endurance and enhanced functionality. To do that, we need a bigger and more stable platform. We topped it with the functionality to run two different payloads, be a sub-bottom profiler, and a multi beam.

## ▀ Do you see these USVs having a more active role in offshore wind energy production as the sector ramps up?

There's quite a parallel between the green-energy movement for renewables and green USVs. When you're getting into the renewable market space, obviously you have a desire to deviate away from the internal combustion engine and bring another option to the market — whether it's something that's not coal, not nuclear, you want to do something new, and that's where wind energy comes in. USVs follow the same path: Most of them, especially the smaller ones, are electrically powered. They're battery powered and recharge-

able. Even the larger ones have a hybrid powertrain, where in fact, a small generator runs and recharges the batteries, allowing it to maintain its endurance and keep going. This reduces reliance on a big diesel or petrol-powered internal combustion engine.

## ▀ Anything else you'd like to mention that we didn't talk about?

In addition to our USVs, we offer comprehensive solutions that extend beyond the vessels themselves. For communication needs, our USVs utilize 4G wireless technology. However, recognizing potential challenges in remote locations, we offer Uni-Mesh — a mesh radio network ensuring secure communications during surveys.

To further facilitate our clients, we provide a deployment case containing first-line consumable spares, regardless of whether it's a rental or a purchase. This Pelican case includes the controller, necessary documentation (checklists, training materials), and essential spare parts, ensuring seamless operations. Our commitment is to offer an all-encompassing solution, making it easy for clients to use our vessels while providing the necessary components to keep them running efficiently. ↵

**MORE INFO** ▀ [www.uniquegroup.com](http://www.uniquegroup.com)

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The Liebherr LRT 1130-2.1 boasts the longest telescopic boom of any two-axle RT. (Courtesy: ALL Crane)

## ► CONSTRUCTION

### ALL Crane to debut new Liebherr rough terrain cranes

ALL Crane will take delivery of Liebherr's newest rough terrain cranes when the ALL family of companies takes delivery of the first five units. The Liebherr LRT 1130-2.1 boasts the strongest-in-class 140-USt capacity and the longest telescopic boom (197 feet) of any two-axle RT.

The LRT 1130-2.1 delivers the most economical transport dimensions of its performance class, being able to be transported on conventional low loaders without disassembly.

"ALL has a tradition of making history when it comes to high-capacity

RTs," said Brian Peretin, general manager, sales, of the mobile and crawler cranes division of Liebherr USA. "ALL purchased the very first units of our 90-ton and the 100-ton RT series when they were first released."

Popular in the North American market, rough terrain cranes are always in high demand for petrochemical maintenance and construction, as well as serving as assist cranes and tail cranes for wind-energy assembly and repair.

"Larger RTs have become a phenomenon in the past 10 to 15 years," Peretin said. "They offer many of the same features of all terrain cranes, but with a smaller footprint, pick-and-carry capabilities, and a smaller cash outlay."

Liebherr developed the LRT 1130-2.1 based on input from heavy RT users such as ALL, who have a feel for what

the market demands.

These first five units are expected to be in high demand for applications requiring a solid load chart, long boom, and the need to fit into tight spaces.

**MORE INFO** [www.allcrane.com](http://www.allcrane.com)

## ► CONSTRUCTION

### Copenhagen to begin construction of India onshore wind project

Copenhagen Infrastructure Partners has taken final investment decision on a 300-MW onshore wind project in India together with Viviid Renewables (Viviid), an Indian developer and balance-of-plant service provider. The



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Copenhagen intends to continue to grow its activities in the Indian market together with both existing and new potential partners. (Courtesy: Copenhagen Infrastructure Partners)

project is in the Indian state of Karnataka with favorable wind conditions, good site accessibility, and a nearby existing grid-connection location. Construction is expected to be completed by the end of 2025.

CIP and Vивиid will develop and construct the wind farm together. Alongside final investment decision, CIP signed equipment orders for the full project capacity. Vивиid will provide balance-of-plant works and services and holds a minority ownership position in the project.

This will be the first project to be constructed under the partnership between CIP and Vивиid, who, in January 2023, entered into a framework agreement to develop at least 1.8 GW of renewable energy projects in India.

“Achieving FID is a significant mile-

stone for CIP and for our partnership with Vивиid,” said Peter Sjøntoft, associate partner at CIP. “It is testament to our industrial approach and ability to deliver large scale renewable energy projects with highly competent partners.”

“We are elated to embark on this first 300-MW wind farm project with CIP and look forward to accelerating the development of renewable assets in India,” said Siddharth Mehra, Vивиid Renewables founder. “Vивиid will leverage its expertise in wind-farm development, including balance-of-plant equipment supplies and services. Through this long-term partnership, we aim to further strengthen our contribution to India’s ambitious target of installing 500 GW of generation capacity from renewable sources by 2030.”



Russelectric manufactures complete systems in-house. (Courtesy: Russelectric)

India is a core market for CI Growth Markets Fund strategy. Since entering the Indian market in 2021, CIP has formed partnerships with AmpIn Energy Transition and Viviid and has opened an office in Mumbai.

**MORE INFO** [www.cip.com](http://www.cip.com)

## INNOVATION

### Russelectric offers cogeneration systems for heat, power

Russelectric, a Siemens business and manufacturer of automatic transfer switches and power control systems, offers UL-listed cogeneration systems

for combined heat and power (CHP) applications in which the generator sets are run to serve the connected load and heat is also recovered for other uses. Designed and built for mission critical facilities such as healthcare, research and development, and campus facilities, Russelectric cogeneration systems are designed to provide maximum protection for operators and maintenance personnel and to minimize the danger of operator error.

All Russelectric cogeneration systems offer programmable logic controller (PLC) system controls, are listed by UL, and are supervisory control and data acquisition (SCADA)-capable. They feature utility/generator and other power assets paralleling control and provide active synchronization and soft loading. Systems use a utility-ap-

proved interconnecting protective relay system.

Russelectric cogeneration power control switchgear may have additional controls and monitoring to optimize heat recovery. The systems can be designed to operate in parallel with the utility to optimize power and heat balance.

Russelectric manufactures complete systems in-house. All enclosures, bus, and other structural components are fabricated and fully assembled in Russelectric plants. Factory testing of complete systems is performed prior to shipment.

Components are selected to assure the reliable operation of critical systems. Switchboard type control switches are rated at a minimum of 25 amps. Protective relays for genera-



tor and utility power are utility-grade. UL-listed power circuit breakers with stored energy closing mechanisms provide 5-cycle (maximum) closing for paralleling.

**MORE INFO** [www.siemens.com/us/en/products/energy/ruselectric/products.html](http://www.siemens.com/us/en/products/energy/ruselectric/products.html)

## INNOVATION

### Plibrico introduces refractory selection guide

The Plibrico Company, a supplier of monolithic refractories, recently introduced an online refractory selection tool designed to guide customers with focused refractory choices tailored to their specific industry and application.

The tool, available at Plibrico's website, is a resource for refractory install-

ers, as well as professionals in the steel, aluminum, off-gas, mineral processing, and power-generation sectors.

By providing industry and equipment details, the selection tool guide identifies Plibrico refractories that offer the optimal blend of structural, thermal, and mechanical properties, along with exceptional overall performance and workability.

Customers can then navigate to the Plibrico Technical Library by selecting one of the recommended refractories. Here, they gain access to technical data, installation guidelines, and safety documents. Selecting the optimal refractory material is a decision that directly affects the efficiency, safety, and overall success of a refractory project.

Using Plibrico's online tool guide, which has already considered essential factors such as temperature resistance, chemical compatibility, and mechanical strength, ensures the chosen refractory material aligns with the demands of the application.

In detail, essential factors considered:

► **Temperature Resistance:** Ensures refractories withstand extreme temperatures, maintaining structural integrity.

► **Chemical Compatibility:** Prevents corrosion and erosion by selecting materials compatible with process chemicals and gases.

► **Thermal Insulation:** Provides heat insulation, improving energy efficiency in industrial processes.

► **Mechanical Strength:** Enhances longevity and resistance to wear, addressing mechanical stresses in diverse applications.

► **Stability:** Ensures consistent performance by improving or maintaining heat transfer, reducing energy consumption, and enhancing production output under varying temperatures and conditions.

► **Application-Specific Tailoring:** Increases productivity and minimizes downtime by optimizing refractory

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The Whitla Wind facility has an installed capacity of 352.8 MW, which allows it to generate enough energy to power more than 100,000 homes per year. (Courtesy: Sarens)

material for industry-specific requirements.

**MORE INFO** [www.plibrico.com/industries](http://www.plibrico.com/industries)

## MAINTENANCE

### Sarens worked on largest Alberta wind facility

Sarens, a leader in heavy lifting, engineered transport, and crane rental services, recently worked on maintenance at the Whitla Wind facility, the largest in Alberta. In this case, Sarens' engineering team was in charge of the lifting of the blades, rotors, gearboxes and main shafts for four turbines (T-79, T-89, T-91 and T-7). The hub height of each tower is measured at 105 meters

and the average weight of the components came in at 31 tons. The Whitla Wind facility has an installed capacity of 352.8 MW, which allows it to generate enough energy to power more than 100,000 homes per year. Located in Forty Mile County, it consists of 98 Vestas V136 wind turbines of 3.6 MW each, with a hub height of 105 meters and a rotor diameter of 136 meters.

According to Capital Power, the company that owns and operates the project, Whitla Wind will prevent the emission of more than 1 million tons of CO<sub>2</sub> per year, equivalent to taking more than 200,000 vehicles off the road. Taking into account the variables to be considered such as component weight, tower height, and access for machinery assembly, the Sarens team of experts selected the Demag CC 2800 Crawler Crane configured with 108-meter Main Boom, 12-meter Luffing Jib, 120Te Main CWT,

20Te Carbody CWT, and 110Te Superlift CWT. This crane was selected because of the height of the towers, as this particular configuration would allow for a boom tip height of 120 meters while remaining under 75 percent of the crane's lifting capacity.

The Whitla turbines are connected to an electrical substation, from where the power is transmitted to the provincial grid via a 240 kV, 34 km high voltage line. The project has a remote-control supervision system, which allows the turbines to be monitored and operated from a centralized control center, ensuring safe and efficient operation.

Sarens has a long history of developing wind projects in Canada. These include the Golden South Wind Project in Assiniboia and the Blue Hill Project in Saskatchewan.

**MORE INFO** [www.sarens.com](http://www.sarens.com)

## MAINTENANCE

# Crowley vessels, crews win environmental awards

The Chamber of Shipping of America (CSA) recently recognized 85 Crowley vessels and their crews for a cumulative 782 years of safe environmental practices and operations.

The Environmental Achievement Awards, presented annually by the CSA, commend vessels and mariners that demonstrate an outstanding safety record with no reportable spills, no U.S. Coast Guard environmental citations, or other pollution incidents.

The Crowley-owned-and-managed vessels recognized by the CSA span diverse categories, including tugs, barges, containerships, tank vessels, and company-managed government ships operating globally.

“We are thrilled to be recognized once again for our safety and environmental stewardship,” said Peter Sutton, vice president of health, safety, security, and environment and operations integrity for Crowley Shipping. “This acknowledgment is a true testament to the hard work and dedication of our mariners and underscores Crowley’s commitment to sustainability and safety within its organization and the maritime industry.”

**MORE INFO** [www.crowley.com](http://www.crowley.com)

## MANUFACTURING

# Vestas plans blade factory in Poland

Vestas plans to establish a new blade factory in Szczecin, Poland. The factory is planned to produce blades for Vestas’ flagship offshore wind turbine, the V236-15.0 MW, and is expected to start operations in 2026, creating more than 1,000 direct jobs. Together with Vestas’ previously announced plans to estab-



The Chamber of Shipping of America awarded 85 Crowley vessels. (Courtesy: Crowley)



The first 3D rendering of the Vestas Poland facility. This preliminary image may differ from the final appearance of the facility. (Courtesy: Vestas Wind Systems A/S)

lish an assembly factory for offshore nacelles in Szczecin, Vestas’ manufacturing footprint could increase with more than 1,700 direct jobs by 2026.

“Vestas intends to lead the development of a sustainable supply chain in Europe that can deliver the scale needed to meet the expected growth

in demand for offshore wind,” said Tommy Rahbek Nielsen, Vestas COO. “Our plans for two new offshore factories in Poland underline that Europe can spur wind industry investments and green jobs with the right long-term policy commitments for offshore wind projects.”



Commissioning for the Steelhead project is set for 2025. (Courtesy: Vestas)



Turbine delivery for the Vestas project in the U.S. begins in 2025's second quarter. (Courtesy: Vestas)

“Poland is transforming its energy system and is a promising wind-energy market with good wind conditions both onshore and offshore,” said Nils de Baar, president of Vestas Northern & Central Europe.

“Poland has a highly skilled labor force and growing wind industry that can become an offshore hub for the Bal-

tic Region and the rest of Europe. We have been a market leader in Poland for more than 20 years, and I am honored to announce our next investment plans in Szczecin.” The new offshore blade factory is planned for at a site in northern Szczecin, which Vestas acquired in February 2023.

The site is close to the Ostrów

Brdowski Island in Szczecin where Vestas’ planned nacelle assembly factory would be located. The assembly factory is expected to start operations in 2025 and create 700 direct jobs.

The new factories are planned to support European and to some extent global demand, playing a crucial role in supporting Poland and the European offshore wind market and industry.

With the two new factories in Szczecin together with Vestas’ already existing footprint, Vestas is expected to soon employ more than 2,500 people in Poland.

Vestas’ manufacturing footprint strategy is to place priority on markets where there’s long-term certainty around market conditions and it has secured a sustainable order volume.

**MORE INFO** [www.vestas.com](http://www.vestas.com)

## MANUFACTURING

### Vestas gets order for Steelhead Americas project

Vestas recently received a 135-MW order to power an undisclosed wind project in the U.S. The order consists of 30 V163-4.5 MW turbines, Vestas’ newest high-capacity factor turbine. The project has been developed by Steelhead Americas, Vestas’ North American development arm.

The order includes supply, delivery, and commissioning of the turbines, as well as a 20-year Active Output Management 5000 (AOM 5000) service agreement, designed to ensure performance of the asset.

Turbine delivery begins in the third quarter of 2024 with commissioning set for 2025. Highlighting its focus on project development in key markets, Steelhead Americas led all development efforts including permitting, land acquisition, and construction design to deliver to the customer a project that is ready for construction and installation.

Steelhead leverages Vestas’ industry

expertise and turbine technology to advance in existing markets and unlock new geographic markets to expand renewable energy across North America.

**MORE INFO** [www.vestas.com](http://www.vestas.com)

### MANUFACTURING

## Vestas secures 167-MW wind project order in U.S.

Vestas has received a 167-MW order to power an undisclosed wind project in the U.S. The order consists of 45 V150 turbines of the 4 MW platform. The order includes supply, delivery, and commissioning of the turbines, as well as a multi-year Active Output Management 5000 (AOM 5000) service agreement, designed to ensure performance of the asset.

Turbine delivery begins in the sec-

ond quarter of 2025 with commissioning scheduled for the fourth quarter of 2025.

**MORE INFO** [www.vestas.com](http://www.vestas.com)

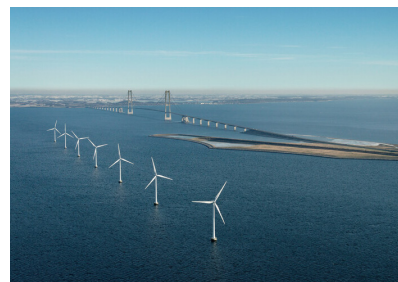
### MANUFACTURING

## Vestas sells 656-MW wind portfolio to Italian producer

Vestas recently sold a 656-MW wind portfolio to Italian renewable energy producer PLT Energia, one of Vestas' most long-lasting customers.

"It is a source of pride for us to have concluded this deal with Vestas, a leading global operator with whom we have been collaborating for years, with great satisfaction, in the realization of wind-power plants," said Pierluigi Tortora, chairman of PLT Holding.

"With this strategic transaction, PLT



Vestas has sold a 656 MW wind portfolio to Italy's PLT Energia. (Courtesy: Vestas)

Energia continues its growth plans in Italy, Europe, and the United States with an under construction and advanced development pipeline of more than 3 GW," said CEO PLT Energia, Stefano Marulli.

Vestas Development holds about 30 GW of wind capacity in its pipeline and has already obtained more than 6.5 GW of firm projects from development activities. ↗

**MORE INFO** [www.vestas.com](http://www.vestas.com)

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# ON OFFSHORE WIND FARMS, SEAFOOD PRODUCTION MAY BE A BREEZE

Sites with offshore wind farms could also be used to grow seafood. (Courtesy: Shutterstock)

*In addition to generating clean energy, sea locations with turbines could be used to grow mussels, oysters, and seaweed.*

By MICHAEL ALLEN

**O**ff the coasts of Belgium, Denmark, Germany, and the Netherlands dozens of wind farms whirl away, helping Europe switch to renewable energy from fossil fuels.

Some of those wind farms are also helping Europe do something few people might imagine: grow seafood. The activity represents a promising new approach to tapping natural resources.

## BUSINESS AS UNUSUAL

Called “multi-use,” it involves the sharing of offshore space and is a big departure from the usual idea of exclusive operating rights.

“Traditionally, most things are done separately,” said Alex Ziemba, a researcher at Deltares, a Dutch institute specialized in water and subsurface. “If you want a wind farm, you put it over there. If people want to go fishing, they go over there. You chop everything up into a nice marine spatial plan, and everyone has their own little areas.”

Ziemba co-led a research project that received EU funding to challenge such thinking by exploring the prospects for sharing offshore sites — a step that will help pave the way for legal questions about co-ownership to be tackled and for possible new jobs to be created.

“The key spot for an offshore wind farm — with optimal wind conditions and siting — might also overlap with a great spot for aquaculture,” he said. “If they’re not combined, only one can use this optimal piece of sea.”

Called UNITED, the project wrapped up on December 31, 2023, after four years. It grew mussels, oysters, and seaweed among the turbines of three wind farms.

## MAKE WAY

While oceans and seas cover 70 percent of the Earth, the room for commercial development in them is far from unlimited. This is especially so in Europe, the second-smallest continent in the world after Australia.

“Space is becoming an increasing problem,” said Dr. Øivind Bergh, a senior scientist at the Institute of Marine Research in Norway. “If you look at a map of Europe and the marine areas for the different countries, quite a lot of countries have very limited space.”

Aside from generating wind energy, countries and businesses have plenty of reasons to look offshore for other economic opportunities. Deploying floating farms for livestock and crops as well as growing seafood are further examples. When practicalities like easy access from a port are taken into account, the prime offshore locations for different industries can often overlap, according to Ziemba.

The UNITED researchers grew the seafood on nets suspended from lines, which were strung out several meters below the water surface to shield them from powerful waves.

The foods grown included blue mussels and various types of seaweed, sometimes in combination with the restoration of oyster beds.

## GOOD GROWTH

While no direct connection existed between the aquaculture systems and the surrounding wind turbines, the coexistence represented a valuable sharing of premium economic space.

At the Dutch test site 12 kilometers from the coast, the nets were home to seaweed. The Belgian site hosted flat oysters as well as seaweed. And the German lines were used to cultivate blue mussels and seaweed.

Young mussels, oysters, and seaweed plants were added to the nets just before they were deployed. The seafood and nets were then monitored via cameras, sensors, and occasional boat trips.

Mussels and oysters can take about two years to reach market size, while seaweed can be harvested more frequently. The resulting yields were comparable to those in calmer nearshore waters and away from other infrastructure, according to Ziemba.

UNITED also collected data on growth rates. That should allow the researchers to model the potential growth rates of larger-scale mussel, oyster, and seaweed aquaculture in future wind farms.

## MARKET OPENINGS

Bergh at the Bergen-based Institute of Marine Research is the scientific head of another EU-funded research project identifying opportunities in the field.

Whereas UNITED mainly involved demonstrating whether combining wind farms and aquaculture was workable, Bergh’s project is more focused on the actual seafood products. Named OLAMUR, it is installing mussel and seaweed aquaculture systems among wind turbines in the Danish part of the Baltic Sea and the German zone of the North Sea. The initiative began in January 2023 and is due to run until the end of 2026.

One demonstration site is in the Danish part of the Kriegers Flak wind farm in the Baltic Sea. This is one of the largest offshore wind sites in Europe.

OLAMUR builds on the work of earlier, smaller projects that focused on the engineering challenges of placing aquaculture systems in wind farms.

The team will study the growth rates and yields of mussels and seaweed as well as their quality. This will involve assessing their nutrient profiles and checking for harmful contaminants to ensure marketability.

## BEYOND SUSHI

The market for seaweed is growing as it finds a role in everything from foods and feed to packaging and medicine.



The market for seaweed is growing as it finds a role in everything from foods and feed to packaging and medicine. (Courtesy: Shutterstock)

For example, large-scale seaweed farming could help clean up Europe's seawater.

In the Baltic and North seas, dead zones have formed as a result of contamination caused by the run-off of nitrates and phosphorus from agriculture. Seaweed feeds on these inorganic nutrients, removing them from the water.

"Those excess nutrients can be transformed from a problem to a resource if you cultivate seaweed," Bergh said.

With the EU committed to protecting at least 30 percent of its seas by 2030, seaweed can play an even bigger role by

reducing agricultural pollution in such places as the Baltic. Any industry can be hesitant about the idea of introducing new activities into ongoing operations and associated risks can never be eliminated altogether, according to Ziemba.

He said that, because wind-energy companies currently don't usually share space, they worry about other infrastructure in the area damaging their turbines and, by extension, disrupting electricity generation.

In the event of a storm, for example, a buoy or longline might break free from its anchor and damage a turbine or



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As part of a study to see if wind-farm space can be shared to grow aquatic agriculture, the growth rates and yields of mussels and seaweed will be measured, as well as their quality. This will involve assessing their nutrient profiles and checking for harmful contaminants to ensure marketability. (Courtesy: Shutterstock)

cause it to stop operating during a recovery operation.

“They need their turbines to operate as often as possible and for nothing to be damaged,” Ziemba said. “But there are clear benefits to combining activities, and some operators are excited about the prospect of doing so.”

### BOTTOM-LINE BENEFITS

A multi-use approach could be a win-win one for all concerned, according to Bergh.

With optimal offshore space becoming tight, domestic permitting procedures often being slow and the EU seeking to ramp up renewables production, developers of a planned wind farm that includes a co-use component could find it easier to get a license.

Beyond that, some clear-cut operational benefits are possible. For example, wind farms and aquaculture producers could cut costs by sharing boats as well as sensors used on vessels, buoys, and turbines to monitor setups.

Ultimately, profitability will determine whether multi-

use offshore locations emerge on more than an experimental basis. The UNITED team is already pursuing a follow-up project in Belgium, Denmark, Germany, and the Netherlands to explore whether aquaculture on wind farms is commercially viable.

“People have to be able to make money from doing it for it to be a business,” Ziemba said. “Otherwise this won’t take off on its own.” ↵

### ABOUT THE AUTHOR

Michael Allen is a U.K.-based science writer. His work focuses on physical and material sciences, sustainability, and climate change. He has appeared in a wide range of publications, from specialist magazines such as *Physics World* to popular titles such as *New Scientist*. Research in this article was funded by the EU. 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.



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