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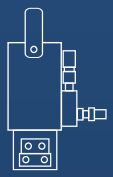

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CONTENTS

10

IN FOCUS

UNLOCKING MORE VALUE FROM EXISTING ASSETS

Repowering is often one of the most cost-effective and environmentally efficient strategies for wind-farm operators managing mature assets.

VALUE EXTENSION OF COMPOSITES

The combination of dynamic reprocessing and chemical recycling provides two complementary pathways for extending the value of epoxy thermoset composites throughout their lifecycle. **14**

PROFILE

For more than 40 years, **Castrol's** range of advanced lubricants for wind turbines has helped improve productivity and reduce overall costs. **18**

THE COVER SHUTTERSTOCK

SECTIONS

◤ THE FUTURE OF WIND

DIRECTION 6

Orsted selects Arenko to deploy Nimbus optimization and trading platform ◤ Denmark energy islands to be game changers ◤ Delta Bravo's PermitPro increases speed for permitting

CROSSWINDS 30

WHY CONNECTION TECHNOLOGY IS FLOATING WIND'S NEXT HURDLE

As floating wind moves from pilot projects to commercial-scale deployment, how the sector designs for disconnection and reconnection will shape the cost and availability of these assets.

TAILWINDS

THE BUSINESS OF WIND

◤ CONSTRUCTION

Statkraft chooses Vestas for Peru wind development. **22**

◤ INNOVATION

Kongsberg launches Aegir SSA family of sonars. **23**

◤ MAINTENANCE

Nexxis Technology acquires BladeBUG robotics company. **27**

◤ MANUFACTURING

CS Wind Offshore selects CNC Onsite for German wind farm. **28**

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Exploring blades, repowering, and more

The wind industry may be seeing a bit of a flux due to political grandstanding in the U.S., but that doesn't mean projects and the companies building them are standing still.

With that in mind, the October issue of *Wind Systems* tackles some important topics, many of which will be important to help the U.S. reach that goal, not to mention the rest of the world.

This issue focuses on blades and repowering — vital subjects that run the gamut from the micro to the macro.

With turbines growing in size and complexity as technology advances, maintenance becomes more of a challenge, particularly when these turbines reach the end of their life expectancy.

Repowering is becoming an essential tool in many a wind developer's tool belt. Repowering an existing wind farm can become the far more economical choice than starting from scratch.

In that vein, October's cover article from Phillip Loy tackles that subject: repowering wind farms and unlocking more value from these existing assets. Repowering is often one of the most cost-effective and environmentally efficient strategies for wind-farm operators managing turbines that are near aging out.

Our second story from Amit Dixit takes a deep dive in the importance of the value extension of composites via a thermoformable and recyclable epoxy system. It gets a bit technical, but, according to Dixit, the combination of dynamic reprocessing and chemical recycling can provide two complementary pathways for extending the value of epoxy thermoset composites throughout their lifecycle.

Crosswinds also offers a topic of interest as author Duncan Black shares his insights on why connection technology is floating wind's next hurdle. As floating wind moves from pilot projects to commercial-scale deployment, how the sector designs for disconnection and reconnection will shape the cost and availability of these assets in the future.

You'll find all that and much more in our October issue. I hope you enjoy it.

As always, thanks for reading!

Kenneth Carter, editor
Wind Systems magazine
editor@windsystemsmag.com
(800) 366-2185, ext. 204

Giving Wind Direction
WIND SYSTEMS

David C. Cooper
Founder

Teresa Cooper
Publisher

EDITORIAL

Kenneth Carter
Editor

Jennifer Jacobson
Associate Editor

Joe Crowe
Associate Editor | Social Media

SALES

Ben Keaten
Vice President | Sales & Marketing

Kendall DeVane
Sales & Marketing

DESIGN

Michele Hall
Graphic Designer

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P.O. Box 1987 • Pelham, AL 35124
(800) 366-2185 • (205) 380-1580 fax
teresa@msimktg.com

Teresa Cooper
President

Clean power has strong momentum in Q2

From American Clean Power

The American Clean Power Association (ACP) recently released its 2026 Q2 Clean Power Quarterly Market Report, highlighting record deployment levels as the clean power industry moves quickly to meet rising energy demand.

Developers brought 164 utility-scale solar, storage, and wind projects online in the second quarter, adding 17.1 GW of new capacity and pushing total clean power capacity to nearly 388 GW, enough to power 83 million American households. The quarter marked the strongest second quarter and first half of a year on record for clean-energy deployments, demonstrating that companies and utilities continue to recognize the value of clean energy as a fast, affordable power source, even in an unstable policy environment. These record-setting results could have been even stronger absent federal actions that have delayed, stalled, or otherwise impeded the development of new clean energy projects.

Utility-scale solar led with 7.4 GW deployed, along with nearly 5 GW of land-based wind, and 4.7 GW of battery storage. Land-based wind recorded its strongest second quarter on record, driven by Pattern Energy's 3.65 GW SunZia Wind project in New Mexico, the largest land-based wind project ever built in the United States. The project produces more energy than the Hoover Dam and will supply power for up to 1 million households across the Western United States.

The clean-energy project pipeline also reached a record high of 205 GW, including 111 GW of utility-scale solar and 56 GW of battery storage. Clean power procurement totaled 14.5 GW, up 23 percent year over year, with power purchase agreement announcements reaching an all-time first-half record. Clean energy projects are the fastest to deploy in a time of rising demand, and companies see the strong business case for clean energy.

Despite the sector's strong performance, federal permitting and review delays threaten future development, particularly for land-based wind projects. More than 11.6 GW of expected clean-power capacity was delayed during the quarter, contributing to a 4 percent decline in the land-based wind pipeline.

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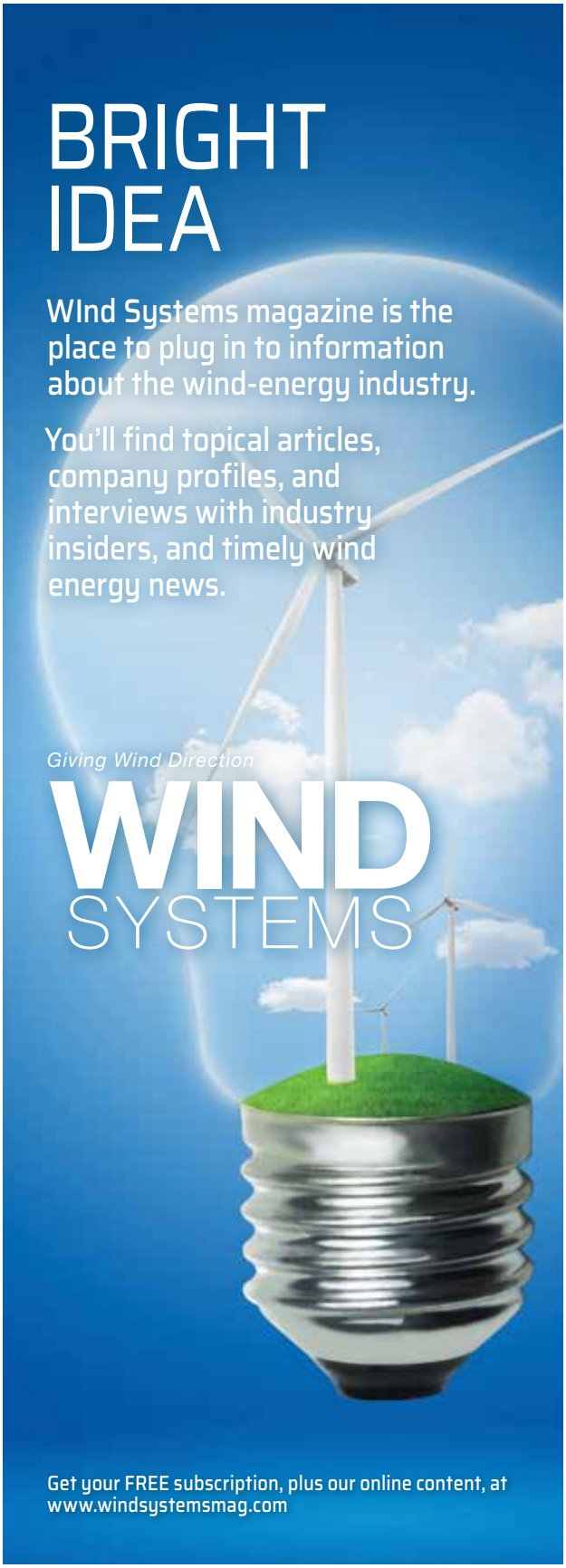


DIRECTION

THE FUTURE OF WIND

Arenko has been selected to deploy its Nimbus platform at Ørsted's Iceni battery, co-located with the 2.9-GW Hornsea 3 offshore wind farm. (Courtesy: Arenko)

Orsted selects Arenko to deploy Nimbus optimization and trading platform

Arenko has been selected to deploy its Nimbus optimization, asset management and trading platform at Ørsted's 300MW/600MWh Iceni battery energy storage project, co-located with the 2.9-GW Hornsea 3 offshore wind farm in the U.K. Iceni is a utility-scale battery directly integrated into offshore transmission infrastructure.

Rather than securing a standalone grid connection, the project will share transmission assets and an onshore grid connection with Hornsea 3 and is scheduled to become operational in Q1 2027.

Iceni is designed to improve coordination between generation and storage assets and maximize the efficient use of existing grid infrastructure.

Under the agreement, Arenko will deploy its full Nimbus platform to manage trading, optimization and Asset Management of the battery asset, as one of the U.K.'s first large-scale "pathfinder" co-location projects under the Offshore Transmission Network Review (OTNR),

Iceni is regarded as one of the most technically and commercially advanced battery developments in Europe, combining utility-scale storage with the operational complexity of a major offshore wind asset, sharing a single grid connection.

"Iceni is a highly sophisticated project, coupling a grid scale battery with one of the U.K.'s biggest offshore wind farms," said Rupert Newland, Arenko CEO. "This creates significant opportunities, but also operational and trading challenges, from forecasting and deciding how and when to allocate capacity in real time, to the technical, data and controls integrations between the two assets. We've worked closely with Ørsted over time as their thinking around flexibility has evolved, and with projects like Iceni, they are taking a pioneering role in bringing truly significant generation capacity and utility-scale storage together. Nimbus is built for that kind of environment, providing the automation and optimization capabilities needed to manage increasingly large and complex assets, across multiple markets."

Iceni has been described by Ørsted and the market as a "blueprint for the future" of co-located energy infrastructure. As a Path Finder project, it is demonstrating how shared grid connections between offshore wind and battery storage can increase output, improve system efficiency, and reduce the need for additional network build-out.

"What makes Iceni interesting for us isn't just the scale of the battery, but how it works alongside Hornsea 3," said Katinka Hussman Palbo, Vice President, Global Trading & Revenue, Ørsted. "We are aiming to optimize two very different assets, wind and storage, through a shared connection point, while ensuring that both deliver significant value to the grid."

Arenko's Nimbus platform is increasingly being adopted to manage and monetize complex co-located projects, having been deployed across 14 large-scale co-location projects to date. Data from existing Nimbus-enabled assets shows automated trading strategies can enable co-located systems to match and exceed the revenue performance of standalone battery projects, with several of these assets performing in the upper percentiles for annualized revenue performance.

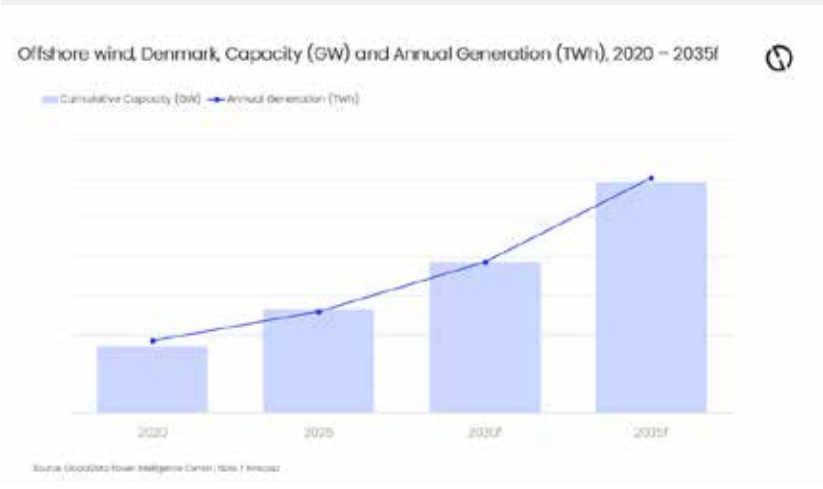
Originally developed in the U.K. BESS market, Nimbus is now deployed across more than 1.2 GW of utility-scale battery, hybrid and renewable generation assets across the U.K., Europe, and the UmS.

MORE INFO arenko.group

GlobalData: Denmark energy islands to be game changers

Denmark plans to establish an artificial island in the North Sea with an initial capacity of 3 GW and another island-based hub at Bornholm in the Baltic Sea. These hubs collect electricity from offshore turbines, transmit power onshore and to neighboring countries, and can convert surplus power into green fuels via Power-to-X technologies.

Denmark's energy islands are not just national assets, they are expected to be regional game changers, according to GlobalData, a leading intelligence and productivity platform.



Offshore wind generation is on the rise in Denmark. (Courtesy: GlobalData)

Delta Bravo Artificial Intelligence, Inc. recently announced its PermitPro is turning one of the government's slowest, most frustrating bureaucratic bottlenecks into a fast, automated, predictable experience. (Courtesy: Delta Bravo)

GlobalData's latest report, "Denmark Power Market Trends and Analysis by Capacity, Generation, Transmission, Distribution, Regulations, Key Players, and Forecast to 2035" reveals the country's electricity generation is projected to increase steadily by 2035, from about 33.6TWh in 2025 to about 43.3TWh, driven by wind power, solar PV, and biopower. Renewable technologies are expected to contribute nearly 98 percent of generation by 2035, with thermal sources receding into backup roles.

More than 8.7 GW of offshore wind projects are in the permitting and announced stages, out of a total pipeline exceeding 17.6 GW. These projects include large-scale developments designed to function not just as wind farms but as artificial energy islands: Platforms that collect, convert, and redistribute offshore-generated power to onshore grids while linking with storage, electrolyzers, and even other islands.

"These islands are envisioned as hubs that will help Denmark deliver more than 55 percent of its gross final energy from renewables by 2030 and achieve full renewable electricity supply shortly thereafter," said Attaurrahman Ojindaram Saibasan,Power Analyst at GlobalData,

With renewables accounting for more than 76 percent of Denmark's installed capacity in 2025 and projected to climb to nearly 87 percent by 2035, a massive flexibility challenge looms. Gas-fired plants, biopower, battery storage, and thermal storage, as well as demand response, will firm up the system as coal fades out completely by 2028.

Electricity trading with Norway, Sweden, and Germany is expected to intensify as artificial islands create opportunities to consolidate offshore generation, produce green hydrogen, and export surplus clean power to neighboring countries. With Denmark's deep interconnectivity already part of the Nordic and EU-wide electricity markets, energy islands could reduce import dependence while strengthening Denmark's role as a net exporter of renewables and hydrogen-derived products.

"Investment in Denmark's offshore wind is surging," Saibasan said. "From 2026 to 2030, the country is expected to deploy nearly one-third of its estimated $9.7 billion investment in offshore wind, with solar PV dominating the rest of the investment, but offshore wind projects offering greater scale and impact. However, building artificial energy islands comes with higher up-front costs, long lead times, and complex technical, regulatory, and environmental trade-offs. Key challenges include securing marine spatial planning, ensuring grid connection rights, building subsea cables, navigating local environmental concerns, and managing supply chain and labor constraints for massive offshore infrastructure."

MORE INFO www.globaldata.com

Delta Bravo's PermitPro increases speed for permitting

Delta Bravo Artificial Intelligence, Inc., a leader in enterprise-grade agentic artificial intelligence (AI) software solutions, recently announced its PermitPro is turning one of the government's slowest, most frustrating bureaucratic bottlenecks into a fast, automated, predictable experience.

It replaces months of permitting red tape with instant or same-day approvals, overhauling an outdated, fragmented energy infrastructure permitting system.

Delta Bravo AI builds agentic AI systems for water utilities, wastewater management, and environmental compliance.

The permitting process for renewable energy projects is multi-layered. The exact type and number of permits (e.g., NEPA, Title V, NDPES) depend on the project's size, geography, technol-

ogy, and jurisdiction. Most projects require approval from local, state, interstate, and federal authorities.

PermitPro, developed by Delta Bravo Artificial Intelligence, Inc. (Delta Bravo AI), is an AI-powered permitting platform that generates, reviews, and validates environmental permit documents up to 95 percent faster than manual processes, while maintaining human oversight. The platform drafts regulation-compliant permits, reviews applications for errors and omissions, and automates repetitive tasks, ensuring final decisions remain with human experts.

"Approval speed depends on the quality of the submissions; missing or mismatched details will cause reviewers to pause the project," said Rick Oppedisano, CEO, Delta Bravo AI. "In the United States alone, tens of thousands of local jurisdictions oversee new energy projects, each with different zoning rules. PermitPro can instantly parse these massive, scattered databases and drastically cuts down the time required to compile, format, and review complex environmental and regulatory applications."

Over the past decade, regulatory and legislative efforts have aimed to accelerate federal permitting. Recommended solutions focus on making permitting faster, more transparent, and legally durable, while maintaining environmental protection and public trust.

The platform is ready for immediate adoption by federal agencies. It integrates with state-supported databases and operates under an AI Risk Management Framework aligned with OMB Memorandum M-25-21, which guides agencies in responsible AI adoption and development.

MORE INFO deltabravo.ai

Synoptic Data signs deal to update weather data hubs

Synoptic Data, a Public Benefit Corporation operating the a real-time environmental data platform, has been awarded a contract by the Met Office to redevelop and provide operational support for EUMETNET's three weather observation data hubs. They are the EUMETNET Aircraft Based Observations Program (E-ABO), the EUMETNET GNSS Water Vapor Program (E-GVap), and the EUMETNET Operational Vertical Profiling Program (E-Profile).

Synoptic Data has been awarded a contract to redevelop and provide operational support for EUMETNET's three weather observation data hubs. (Courtesy: Synoptic Data)

This project will modernize critical infrastructure that enables weather observation sharing across National Meteorological and Hydrological Services (NMHSs), ensuring reliable, secure, and scalable access to environmental observations for forecasting, research, and operational decision-making.

The E-ADAS (EUMETNET AMDAR Data Acquisition System) Datahub processes AMDAR observations from European airlines that are part of the EUMETNET aircraft-based observations program (E-ABO). The E-Profile Datahub processes data observing instruments that vertically profile the atmosphere, including radar wind-profilers, weather radars, Doppler wind Lidar, microwave radiometers, automatic Lidars, and Ceilometers. The E-GVap Datahub receives meteorological observations from geodetic centers and converts these into a format that can be used by NMHSs.

"We are delighted to be working with Synoptic to modernize these three important EUMETNET data services," said Dr. Jacqueline Sugier, EUMETNET Observations Capability Area Manager, Met Office.

"Observations are the foundation of weather forecasting. The redevelopment of these three data hubs will strengthen the resilience and long-term sustainability of the infrastructure that underpins the exchange of aircraft, GNSS water vapor, and vertical profile observations. This investment will ensure that meteorological services around the world continue to benefit from reliable access to the trusted observations shared by our European partners, supporting services for the communities they serve,"

Weather observations are critical for the safety of all communities throughout the world as well as the economy.

Through this new contract, Synoptic will modernize EUMETNET's three data hubs, providing reliable access, quality control, data consistency, and secure delivery of aircraft-based observations, vertical profiler observations, and GNSS water vapor observations. The modernized platform will help ensure that meteorological services across the world have dependable access to the observations needed for weather forecasting, analysis, and climate research.

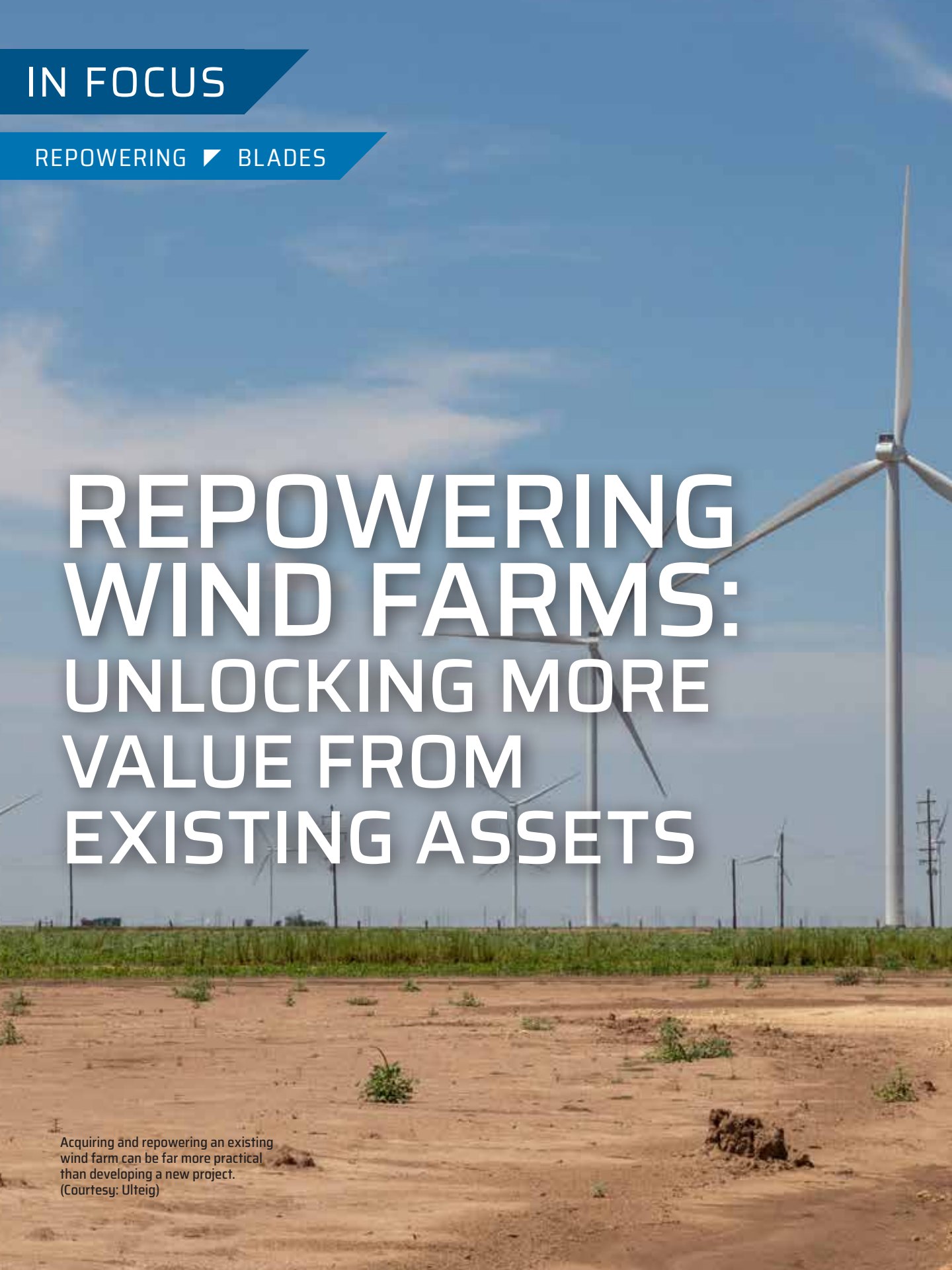
The project reflects a growing global emphasis on modernizing environmental data infrastructure to support faster, more informed decision-making.

Reliable, low-latency access to real-time weather observations, and the ability to securely exchange those observations across organizations, has become increasingly important for operational forecasting, climate monitoring, and research.

By modernizing EUMETNET's data services, Synoptic will help ensure these observations remain accessible, scalable, and dependable for years to come.

MORE INFO www.synopticdata.com

REPOWERING WIND FARMS: UNLOCKING MORE VALUE FROM EXISTING ASSETS



Acquiring and repowering an existing wind farm can be far more practical than developing a new project. (Courtesy: Ulteig)

Repowering is often one of the most cost-effective and environmentally efficient strategies for wind-farm operators managing mature assets.

By PHILLIP LOY

Wind remains a major contributor to the U.S. energy mix, but one of the sector's most significant growth opportunities may come less from new footprints and more from existing ones.

According to the US Energy Information Administration, wind and solar together generated a record 17 percent of U.S. electricity in 2025, with wind alone producing 464,000 GW/h. At the same time, a growing share of the U.S. wind fleet is reaching the point where owners must weigh the cost of maintaining aging equipment against the value of upgrading it. Repowering is becoming an increasingly practical way to extend project life, improve performance, and capture more generation from sites that already have land rights, infrastructure, and grid access.

Wind technology has advanced rapidly over the past decade. Newer turbines use larger rotors, taller towers, and more sophisticated controls to capture more energy at a lower cost per megawatt-hour. According to the U.S. Department of Energy, wind turbines continue to grow in size and power, with the average nameplate capacity of newly installed wind turbines at 3.5 MW in 2024, compared to about 2.8 in 2020.

Let's put it another way: A single, 3.5-MW typical wind turbine installed today can generate enough electricity to power 1,000 average American homes for an entire year, a significant increase over the average 2.8 MW wind turbine built in 2020 that could power approximately 800 homes (epa.gov). In practical terms, this means owners can increase production with fewer machines and a smaller maintenance burden.

But these results are not just limited to newly built wind farms using the latest technology.

FACTORS TO CONSIDER FOR REPOWERING

Repowering decisions typically begin with a straightforward question: Does it make more sense to continue maintaining legacy equipment or to upgrade key components or entire turbines to capture more value from an existing site? For many project owners, the answer increasingly depends on how older assets compare with today's technology in output, reliability, and long-term operating cost.

According to data analytics firm Wood Mackenzie, many owners are already using upgrades to extend asset life and

Repowering decisions typically begin with a straightforward question: Does it make more sense to continue maintaining legacy equipment or to upgrade key components or entire turbines to capture more value from an existing site? (Courtesy: Shutterstock)

improve project economics, forecasting that global cumulative repowering capacity will increase from just more than 21 GW in 2023 to 134 GW by 2033. It notes, "Repowering a turbine by replacing an aging platform with a newer, larger model is the most effective way an operator can increase the efficiency and output of their wind portfolio."

Recent academic research on the long-term opportunity in the U.S. backs this up, suggesting that under the right conditions, repowering existing U.S. onshore wind sites could more than double the current nameplate capacity from 153 GW to about 314 GW.

For owners evaluating mature assets, that potential makes repowering not just a maintenance decision, but a strategic generation and infrastructure decision.

For owners evaluating whether a project is a strong candidate for repowering, several indicators tend to merit closer review, particularly when site conditions and wind resources remain favorable:

- **Age:** Projects commissioned a decade or more ago often use turbines that are substantially smaller and less efficient than those available today. That gap alone can justify a performance and economic assessment.
- **Performance trends:** Declining output over time may indicate turbine deterioration, technology limitations, or site-specific constraints that warrant closer analysis.
- **Maintenance costs:** Rising spending on blades, drivetrains, and other major components can shift the economics toward repowering, particularly when downtime and long-term reliability are factored in.

A repowering assessment usually considers several interrelated factors:

- **Maintenance cost trajectory:** How quickly operating and repair costs are increasing as infrastructure ages.
- **Replacement cost exposure:** The cost and availability of major components needed to keep legacy turbines operating.
- **Opportunity cost:** The potential for newer equipment to increase generation, improve availability, and strengthen project economics.
- **Interconnection implications:** Whether increased output would trigger upgrades, amendments, or new interconnection requirements.

Repowering is often one of the most cost-effective and environmentally efficient strategies for wind-farm operators managing mature assets. Many core components, such as substations, transmission lines, underground cables, and transformers can last up to 40 years, and repowering allows operators to fully leverage that long-term infrastructure. In today's environment, where interconnection queues and permitting processes often take years to complete, sites that are already online offer a distinct advantage.

Acquiring and repowering an existing wind farm can be far more practical than developing a new project from the ground up and often has minimal regulatory approvals as compared to a new site.

Certainly, for projects with strong wind resources, established site control, and viable interconnection infrastructure, routine repowering assessments can help owners lower lifecycle costs, extend asset life, and generate more energy from land already in service.

ABOUT THE AUTHOR

Phillip Loy is an Ulteig renewable lead engineer.

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VALUE EXTENSION OF COMPOSITES VIA THERMOFORMABLE AND RECYCLABLE EPOXY SYSTEM

For applications such as wind energy, automotive and transportation, aerospace, and industrial composites, the ability to modify a cured component can provide additional flexibility throughout its lifecycle. (Courtesy: Shutterstock)

The combination of dynamic reprocessing and chemical recycling provides two complementary pathways for extending the value of epoxy thermoset composites throughout their lifecycle.

By AMIT DIXIT

Epoxy thermosets have long been a material of choice for high-performance composites, structural adhesives, and protective applications. Their unique combination of mechanical strength, thermal stability, chemical resistance, and long-term durability makes them particularly well suited to demanding applications where structural integrity is critical.

However, the crosslinked network that gives thermoset epoxies their exceptional performance also creates a fundamental lifecycle challenge. Once cured, conventional epoxy systems are permanently crosslinked, limiting their ability to be reshaped, reprocessed, or recycled. While thermoplastics offer greater flexibility through their ability to soften and be reshaped with heat, they often cannot match the mechanical performance in many structural applications.

For the composite industry, this presents an important question: Can a thermoset deliver performance expected during service while offering greater flexibility at the end of manufacturing and at the end of its useful life?

The innovative thermoformable and recyclable epoxy system offers a unique solution to extend the value of high-performance composites. Leveraging the proprietary Recyclamine® technology platform, the novel epoxy system incorporates dynamic and cleavable functionality into a single network. This advanced polymer network integrates the performance characteristics of conventional crosslinked thermosets with thermoformable, repairable, and reprocessable functionality, while simultaneously enabling closed-loop chemical recycling and end-of-life material recovery.

By integrating performance and circularity into the same material platform, this next-generation epoxy technology extends the value of high-performance composites across their entire lifecycle. The result is a new approach to epoxy-based composites that supports manufacturing flexibility, facilitates repair and reuse, and creates viable pathways for material recovery without compromising the performance expected of advanced thermoset systems.

THERMOFORMABILITY WITHOUT SACRIFICING THERMOSET PERFORMANCE

The difference between a conventional epoxy matrix and the innovative dynamic thermoformable epoxy becomes particularly relevant during thermal processing.

A conventional epoxy thermoset cannot readily retain or adopt a new defined geometry once it has been fully cured. By contrast, the dynamic thermoformable epoxy system remains capable of reforming and undergoing controlled shape change, allowing components to be formed into a new geometry under appropriate temperature conditions.

Importantly, this capability does not require abandoning the performance characteristics associated with a thermoset network. Tests demonstrate that the grinded material from cured thermoformable epoxy can fuse under heat and compression at 180°C for 30 minutes retaining significant level of its original mechanical performance unlike the conventional epoxy that remains infusible. (See Figure 1)

Figure 1: Comparative thermoformability performance of conventional and dynamic epoxy thermosets.

FROM PERMANENT CROSSLINKING TO DYNAMIC NETWORK FUNCTIONALITY IN COMPOSITES

The key to the propertiary technology lies in response of the crosslinked epoxy matrix to temperature. Under normal service conditions, the crosslinked structure remains stable, providing the dimensional integrity, mechanical performance, and durability expected from a thermoset. When exposed to controlled elevated temperatures, however, dynamic bonds within the network can exchange and rearrange.

This network rearrangement allows thermoset composites to change shape and reform without simply melting, flowing, or degrading. In practical terms, the cured epoxy matrix is thermoformable, enabling controlled shape change and stress relaxation while maintaining the overall integrity of the crosslinked network in composites. (See Figure 2)

The capability opens new possibilities for composite manufacturing and service, including thermoforming, repair, rework, and reshaping of cured components.

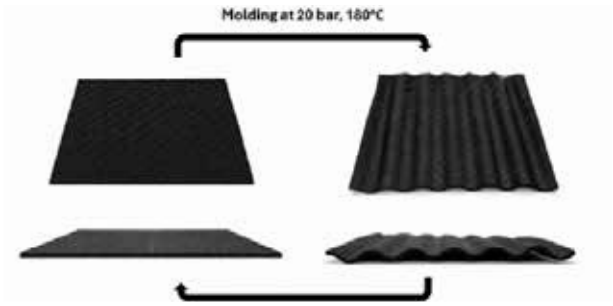

Figure 2: Thermoforming and shape-memory behavior of an epoxy-based carbon-fiber-reinforced (CFRP) composite, demonstrating shape transformation and recovery under controlled heating.

For applications such as wind energy, automotive and transportation, aerospace, and industrial composites, the ability to modify a cured component can provide additional flexibility throughout its lifecycle. Manufacturing defects or design changes can potentially be addressed without replacing the entire component, while repair and reshaping can help extend the useful life of high-value composite structures.

EXTENDING THE COMPOSITE LIFECYCLE THROUGH REPAIR AND REPROCESSING

Thermoformability introduces another dimension to composite lifecycle management: the ability to extend the useful life of a cured composite structure as long as its mechanical properties meet the application requirement.

Rather than treating curing as the irreversible final step in the manufacturing process, the dynamically reprocessable epoxy network enables cured components to be modified, repaired, and potentially repurposed when required. This shifts the perception of a composite part from a fixed, end-state structure to an adaptable asset with continued value beyond its initial manufacture.

In manufacturing, this could help accommodate changes in component geometry or address certain processing issues. During service, the same capability could support repair or rework strategies. For high-value composite structures, extending the useful life of an existing component can be an important part of reducing material consumption and preserving the value embedded in the original manufacturing process. The technology therefore moves the discussion beyond conventional recyclability. Instead of focusing only on what happens after a component becomes waste, it introduces the possibility of maintaining, adapting, and reusing the component before it reaches end of life.

CHEMICAL RECYCLING: RECOVERING EPOXY MATRIX AND REINFORCEMENT IN COMPOSITES

The thermoformable system offers second capability to chemically recycle composites at the end of its service life. The dynamic network incorporates cleavable functionality that enables the cured epoxy matrix to be chemically deconstructed through solvolysis under controlled recycling conditions. This provides a pathway to separate the polymer matrix from the reinforcing material. (See Figure 3)

For composites, this is particularly relevant because, rather than treating an end-of-life component as waste destined for landfill or incineration, chemical deconstruction creates an opportunity to recover the reinforcement and retain more of the material value within the manufacturing cycle.

The solvolysis using a chemically benign solution converts the epoxy matrix into a thermoplastic material while allowing the reinforcements to be recovered. The recovered reinforcements retain their integrity enabling re-use to manufacture new composites. The epoxy matrix recovered as a thermoplastic has inherent properties similar to traditional thermoplastics.

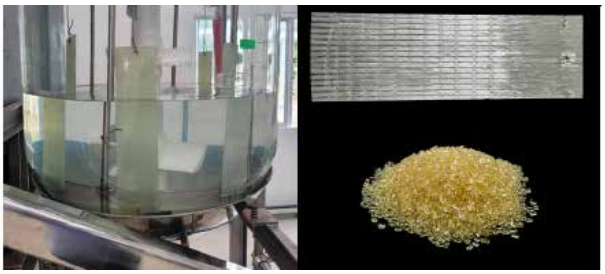

Figure 3: Illustration of the solvolysis-based chemical recycling of glass-fiber-based composite, showing polymer matrix deconstruction and recovery of reinforcement and thermoplastic material.

This creates a potential pathway in which both sides of the composite — the epoxy matrix and the reinforcement — can have a route to a subsequent new life. For composite manufacturers, this distinction is important. Recycling is not simply about diverting material from landfill or incineration; it is about preserving material value and creating viable routes for recovered materials to re-enter manufacturing.

ONE EPOXY PLATFORM, TWO PATHWAYS FOR LIFECYCLE FLEXIBILITY

The combination of dynamic reprocessing and chemical recycling provides two complementary pathways for extending the value of epoxy thermoset composites throughout their lifecycle. During manufacturing and service, thermoformability enables cured components to be reshaped, repaired, reworked or reprocessed under controlled thermal conditions. At end of life, chemical recycling through solvolysis provides a pathway for deconstructing the epoxy matrix and recovering the matrix and fiber reinforcements for subsequent composite applications. Together, these capabilities offer a different way to think about thermoset composites. A thermoset no longer has to represent the end of a material's useful journey once it has been cured.

By combining the high-performance characteristics of epoxy with dynamic network functionality and chemical recyclability, this technology provides a pathway toward keeping composite components in service longer and recovering valuable materials when they ultimately reach end of life.

For an industry increasingly focused on resource efficiency and lifecycle value, the opportunity is not simply to make composites recyclable. It is to design greater flexibility into the material itself — so that one epoxy platform can support multiple stages of a composite's lifecycle. Two capabilities. One epoxy platform. More than one lifecycle.

ABOUT THE AUTHOR

Amit Dixit is senior vice president at Aditya Birla Advanced Materials. He is a global R&D leader with more than 25 years of professional experience in materials science, specializing in advanced polymer and epoxy technologies. He has spearheaded the development and commercialization of multiple applications, breakthrough products, and core industrial technologies on a global scale.

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PROFILE

CASTROL

PROVIDING ADVANCED ASSET PROTECTION

As a global organization, Castrol has teams all over the world with expertise in dealing with a variety of different environments. (Courtesy: Castrol)

For more than 40 years, Castrol's range of advanced lubricants for wind turbines has helped improve productivity and reduce overall costs.

By KENNETH CARTER ◤ Wind Systems editor

Let's start with the obvious: Today's wind turbines are enormous. Keeping them turning and creating power throughout their lifetime can sometimes be a bit more .. complicated.

There are many checks and balances and necessary equipment needed to perform that complex task, but nothing may be more essential than the lubricants within the turbine itself.

To that end, Castrol has been creating lubricants for wind turbines since the early 1980s, according to David DiNunzio, Wind Key Account manager, North America.

EXPANDING ITS WIND KNOWLEDGE

In 2000, Castrol was acquired by BP as the company began to expand its presence in alternative energy, including wind. These investments focused on building and operating wind farms, especially in the United States, according to DiNunzio.

"That gave us some really unique insight into the wind business," he said. "Today, it continues to give us a unique opportunity to look at what challenges the OEMs face when they're building and constructing, and also the responsibilities of the site teams. It gives us valuable perspective that helps us bring the best solutions and develop products to meet new technology as it continues to evolve."

One of the challenges facing lubricant providers, like Castrol, is the continued growth of the turbines themselves, according to DiNunzio.

"Unfortunately, everything doesn't scale along with the power output," he said. "In the past, turbines were small — around 200 to 400 kW — mounted on lattice towers. Today, we're dealing with machines in the 4 to 6 MW range, which are massive pieces of equipment."

One of the biggest engineering challenges that comes with this scale is weight.

According to DiNunzio, turbine manufacturers are very cautious about placing large or heavy components at the top of the tower, since doing so can introduce significant safety risks. He noted that the high power output required from modern turbines puts substantial additional stress on the gearboxes, main bearings, and the entire drivetrain.

"The power ratio these turbines have to put out puts a lot more stress on the gearboxes and main bearings — the whole drivetrain," he said. "It just brings a lot of safety hazards with it."

THE POWER OF LUBRICATION, NOT JUST LUBRICANTS

To address the challenges, both large and small, Castrol works with customers to focus on the "total cost of ownership," according to DiNunzio.

"What truly impacts a plant's profitability isn't the upfront price of the lubricant, but how it performs over time," he said. "Castrol's philosophy is centered on delivering the lowest total cost of ownership through performance, reliability, and advanced technology. In wind, where turbines operate under extreme conditions and service access is limited, our focus has always been on maximizing lubricant technology to extend component life, reduce failures, and simplify maintenance."

DEALING WITH DIFFERENT ENVIRONMENTS

When it comes to total cost of ownership, operating environment matters because wind turbines face vastly different conditions that directly affect reliability and maintenance, according to DiNunzio. Understanding the distinct environments in which wind turbines are built is a critical part of the equation. Total cost of ownership is ultimately shaped by where the turbine operates, because the environment — whether offshore, coastal, or inland — directly affects lubricant performance, component life, and the overall value discussion.

"They're not sitting in one, neat, sunny climate," he said. "They're all over the United States — and really, all over the world. That's why we have to make products that are flexible to handle those different environments that turbines face."

Offshore wind also has its own set of challenges, according to DiNunzio, which is why offshore turbines tend to be a little more robust.

"Offshore environments make serviceability even more challenging, so longer-lasting products that extend equipment life become essential," he said. "Servicing a turbine 300 feet in the air is difficult on its own — adding a boat trip into open water makes it even tougher. That's why we design products built for these conditions, with broad OEM approvals across multiple platforms."

With that in mind, Castrol wants to ensure turbines get the best lubrication wherever they're located, according to DiNunzio.

"We need our technology to perform everywhere — from the equator to the far north, offshore or onshore," he said.

FINDING THE BEST SOLUTIONS

Staying on top of the latest developments is just part of how Castrol develops the ideal solutions for its clients, according to DiNunzio.

"There's a lot of competition in the industrial and wind space," he said. "We're all working to advance technology, understand emerging challenges, and anticipate where the industry will be in a few years. Developing, testing, and field validating new solutions takes time, so we have to project five to six years out and plan for the challenges ahead we're going to face. That's how we balance cost and technology to deliver the most value for our clients."

As a global organization, Castrol has teams all over the

Castrol's vast timeline of expertise mean the company has brought a lot of unique solutions to the industry. (Courtesy: Castrol)

Castrol was one of the first lubricant companies to develope products specific for the wind industry. (Courtesy: Castrol)

world with expertise in dealing with a variety of different environments, according to DiNunzio.

"As you would expect, our teams in Europe have deeper experience with offshore turbines, while here in the United States the sheer number of onshore turbines gives us a strong base of knowledge, especially through our connection with the bp wind team," he said. "We focus on asking customers the right questions and engaging the right people. It's very important to get the opinion of the people in the field that see it firsthand. Input from field technicians, along with engineering and reliability teams, helps us understand the scale of an issue. From there, we can involve data scientists and specialists who monitor predictive technologies. Oil analysis is a core expertise for us, but we also rely on vibration analysis, temperature monitoring, and other diagnostic tools to pinpoint what's going on. We draw on experience, ask targeted questions, and we're not afraid to pull in other ex-

Staying on top of the latest developments is just part of how Castrol develops the ideal solutions for its clients. (Courtesy: Castrol)

> We focus on asking customers the right questions and engaging the right people. It's very important to get the opinion of the people in the field that see it firsthand.

perts as needed. Troubleshooting is always better with more than one opinion."

DEVELOPING WIND-SPECIFIC PRODUCTS

Castrol's vast timeline of expertise mean the company has brought a lot of unique solutions to the industry, according to DiNunzio.

"We've developed products specific for the wind industry," he said. "We were one of the first lubricant companies to do that. We've pioneered technology that allows gear oil to be reconditioned uptower, which extends oil life and, in turn, equipment life — reducing the amount of service required, which I've dedicated a lot of time to testing and proving out the main bearing greases we've launched over the past eight years. They've boosted reliability across many platforms, earning approvals from nearly every OEM — proof of our product advantages and the industry experience behind them."

FUTURE OF WIND

Despite the current political client when it comes to wind energy, DiNunzio said he isn't worried about the future state of the industry.

"The industry naturally cycles up and down, and wind industry has operated this way for a long time," he said. "With its dependence on the tax code, fluctuations are expected, but I am confident wind will keep growing quickly. Our energy needs are enormous, and any viable source will be highly sought after."

It's also important to remember that wind energy as a power source is still very young compared to others, according to DiNunzio.

"It's remarkable to see how far the industry has come in the 40 years we've been involved," he said. "Turbine designs have changed rapidly, and we've evolved our lubrication technology right alongside them. The materials we use today are completely different from what we used in the '80s."

Wind is still a young industry compared with traditional power sources, according to DiNunzio.

"It's learning how to scale, improve reliability, and support larger machines," he said. "That's where we fit in — developing solutions that help operators grow and get more energy from the wind. I'm excited about where wind is headed, which is why I've dedicated the past 10 years to it and expect to see even more growth ahead."

MORE INFO: www.castrol.com/wind-u

Statkraft chooses Vestas for development of the 72-MW Emma Wind Farm in Peru. (Courtesy: Statkraft)

CONSTRUCTION

Statkraft chooses Vestas for Peru wind development

Statkraft Peru, a leading renewable energy generation company and subsidiary of the Norwegian state-owned company Statkraft, recently selected Vestas for the development of the 72-MW Emma Wind Farm in the Piura region of Peru. This project marks Vestas' return to the Peruvian market with its 4-MW platform and reinforces both companies' commitment to the energy transition and the country's sustainable development.

Under this contract, Vestas will be responsible for the supply and installation of 16 V163-4.5 MW wind turbines, with a hub height of 119 meters. Delivery of the main components is scheduled for the second quarter of 2027, while turbine commissioning is expected in the first quarter of 2028.

"We are very proud to support Statkraft in the development of the Emma Wind Farm," said Andrés Gismondi, Vice President of Sales at Vestas for the Southern Cone and Northern Latin America. "This project reinforces our confidence in Peru's growth potential as one of the most attractive renewable energy markets in the region. Wind energy will continue to play a key role in diversifying the country's energy mix, delivering competitiveness, security, and long-term sustainability. We remain committed to supporting the development of Peru's energy sector with cutting-edge technology, local expertise, and solutions that create value for our customers and the local economy."

This new project strengthens the presence Vestas has built in Peru over more than 10 years through the operation and maintenance of 62 wind turbines, totaling 100 MW of installed capacity.

MORE INFO www.statkraft.com

CONSTRUCTION

Liebherr introduces CBG 310 grab crane upgrade

With the introduction of the CBG 310, Liebherr Maritime Cranes advances high-performance transshipment through a measured evolution of its four-rope grab crane portfolio. Developed as the direct successor to the CBG 300, the new model reaches a maximum hoisting speed of 130 meters per minute, representing an increase of 44 percent and enabling faster handling

With the introduction of the CBG 310, Liebherr Maritime Cranes advances high-performance transshipment through a measured evolution of its four-rope grab crane portfolio. (Courtesy: Liebherr)

cycles with reduced vessel turnaround times.

Its lifting capacity rises to up to 45 tons on hook, while a standard boom length of 30 meters ensures continuity for floating applications, with an extended outreach of up to 32 meters available for land-based installations.

Operator conditions have also been improved with an enlarged cabin volume of seven cubic meters, enhancing comfort and visibility during extended shifts. At the same time, the transition from hydraulic hoses to integrated piping within the slewing column reduces maintenance exposure and supports lower lifecycle costs. All of these features deliver a balanced improvement in performance, efficiency, and operational reliability.

For operators running CBG 300 cranes, the transition to the CBG 310 represents a natural and performance-driven progression. Rocktree, a global transshipment and logistics provider that optimizes the movement of dry bulk commodities, decided to replace its two CBG 300 cranes after 11 years of continuous service, which demonstrates the tangible benefits of the new generation. By maintaining the eccentric-arm configuration, the upgrade to the CBG 310 preserves proven geometry while enabling higher throughput and improved responsiveness in daily operations. The project also marks a significant milestone, with Rocktree becoming the first operator to install CBG 310 cranes on eccentric-arms, reflecting the company's pioneering approach to advancing transshipment solutions through proven yet forward-looking technology.

Faster cycles, combined with enhanced grab performance, support increased turnover rates and contribute directly to reduced vessel idle time. This ensures transshipment operations remain both efficient and predictable, even under demanding conditions where consistency is essential.

Beyond structural enhancements, the CBG 310 introduces an expanded digital layer that supports a more controlled and intuitive operating experience. At its core is Liebherr's Litronic control system, enabling precise and consistent crane movements even under challenging transshipment conditions.

The CBG 310 is designed for operators who expect more from a proven concept," said Tim Ladendorf, Head of Sales Ship Cranes, Port and Transshipment Solutions at Liebherr-Rostock GmbH. "It delivers a clear step forward in capability while preserving the handling philosophy that crews know and trust."

MORE INFO www.liebherr.com

INNOVATION

Kongsberg launches Aegir SSA family of sonars

Kongsberg recently announced the launch of Aegir SSA (Subsea Situational Awareness), a new family of sonars designed to improve maritime security, safety, and navigation through continuous underwater awareness.

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Unveiled at ONS 2026 in Stavanger, the Aegir range represents a new generation of commercial sonar solutions developed to meet the growing need for situational awareness around ports, critical infrastructure, coastal areas, and offshore assets.

Based on more than 80 years of sonar experience, Aegir combines high-performance acoustic technology with compact form factors, simplified integration, and scalable deployment options ranging from small uncrewed surface vessels (USVs) and buoys to fixed installations and larger maritime platforms.

As part of the Aegir SSA concept, Kongsberg offers an AI-powered virtual sonar operator service that enables operation without continuous human involvement.

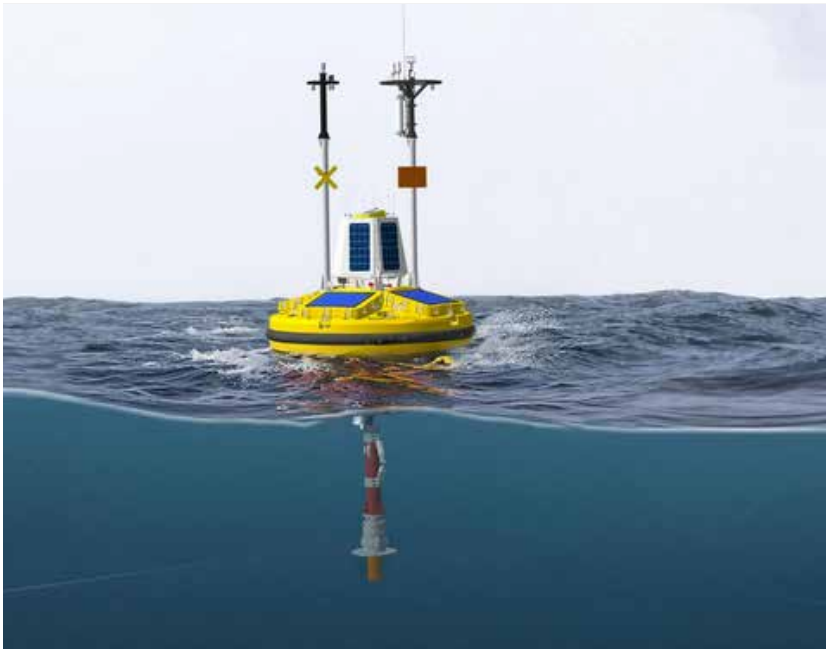
The AI can be configured for specific missions and trained by customers' own operators to retain and apply their operational knowledge.

As maritime infrastructure becomes increasingly important to energy security, transportation, offshore operations, and national resilience, operators require better visibility below the waterline.

The Aegir family is designed to provide operators with actionable underwater awareness, enabling detection, classification, and tracking of objects and activities beneath the surface while supporting safer navigation and more informed decision-making.

"The underwater domain has become a critical operational environment for both commercial and government operators," said Helge Andre Sundt, VP Subsea Awareness, Kongsberg. "With Aegir SSA, we are bringing Kongsberg sonar expertise into a purpose-built product family designed to enhance security, safety, and operational awareness in demanding maritime environments."

As part of the launch, visitors to ONS will be able to view a live data feed from an operational Aegir SSA sonar installation located in the Oslofjord. The system is integrated on Fugro's SEAWATCH® buoy platform connected to the Oslofjord Testbed, combining persistent offshore monitoring, real-time data delivery, and advanced subsea sensing to enhance protection of critical maritime infrastructure.



Kongsberg has launched Aegir SSA (Subsea Situational Awareness), a new family of sonars. (Courtesy: Kongsberg)

Ahead of the commercial launch, Kongsberg collaborated with Fugro to deploy Aegir SSA on a SEAWATCH® buoy connected to the Oslofjord Testbed, demonstrating how fixed monitoring infrastructure can support continuous protection of critical maritime assets.

"As the need to protect critical undersea infrastructure continues to grow, operators need reliable and scalable monitoring solutions that provide continuous situational awareness," said Hompe Heijmerink, Fugro's Director of Maritime Security and Surveillance for Europe and Africa.

"Combining Kongsberg's new Aegir SSA sonar with Fugro's proven SEAWATCH® buoy platform creates an always-on monitoring solution that helps safeguard critical maritime assets while providing operators with actionable real-time intelligence for faster decision-making."

MORE INFO www.Kongsberg.com

INNOVATION

Stillstrom removes barrier to vessel charging in wind farms

Stillstrom by Maersk has proven that offshore vessel charging can be fully automated, removing one of the practical barriers to hybrid and electric support vessels operating on dynamic positioning (DP) in offshore wind farms.

Connecting a vessel to an offshore power source while it holds position on DP means managing a moving cable safely, a task that has traditionally needed manual oversight and carries cost and risk.

A trial of the Stillstrom Offshore eCharger (SOeC), witnessed by DNV as part of its technology qualification process, demonstrated Stillstrom's cable control system managing the cable automatically, from initial connection through to the vessel returning to position. The trial was performed in collaboration with offshore wind vessel operator ESVAGT and Semco Maritime, a long-term development partner

for Stillstrom, which helped set up the test from its yard in Esbjerg, Denmark.

During the trial, the charging connector was deployed to the vessel from a height of 15.5 meters, representative of the wind turbine or substation height at which a Stillstrom system would be mounted in the field. The cable reel on the tower held 125 meters of cable, with the technology automatically paying out more cable as the vessel moved further away and reeling it back in as it returned, maintaining a constant cable profile throughout.

The trial tested five elements: control system performance for automated cable control, RTK GPS as a position reference for that control, synchronized line speed between the tower-mounted cable reel and the electric pull-in winch placed on the vessel, the user interface and logging features for monitoring and data collection, and the system's behavior under realistic yard conditions.

"Cable control is one of the trickier parts of offshore charging to get right, and this successful trial showed our system safely managing it automatically as the vessel moves and communicating reliably well beyond our planned range," said Stillstrom CEO Kristian Borum Jørgensen.

"None of this happens without having the right partners in the room, and ESVAGT and Semco Maritime have helped drive this forward. This is another meaningful step, giving the sector further confidence in our offshore power and charging solution as we move towards full-scale deployment."

Stillstrom has been pioneering offshore power and charging solutions to decarbonize the maritime sector from its bases in Copenhagen and Aberdeen and is on the cusp of commercial rollout. This latest assessment followed yard and harbor trials carried out in 2024 and a dry test completed in February 2026. The next step is a more integrated test involving an SOV and the full system, ahead of an eventual sea trial for final certification, which may also serve as the technology's first deployment.

MORE INFO stillstrom.com

INNOVATION

Vaisala launches service portfolio Vaisala Care

Growing data centers require a new approach to managing measurement performance. Driven by AI, cloud infrastructure, and digital services, facilities are becoming larger and more complex, creating new challenges in maintaining the accuracy of measurements that help support cooling performance, energy efficiency, and uptime.

To help address this challenge, Vaisala, a leader in measurement instruments and intelligence, has launched

Vaisala Care for Data Centers. The new service portfolio helps operators maintain measurement accuracy, operational reliability, and uptime throughout the lifecycle of their measurement systems.

Data centers depend on accurate environmental measurements to support cooling performance, energy efficiency, operational reliability and uptime objectives. A single facility may contain hundreds of instruments monitoring numerous parameters, creating an ongoing need for calibration, verification, and documentation.

As facilities continue to grow, maintaining measurement performance becomes increasingly complex. Even small measurement deviations can affect cooling efficiency, increase operational risks, and impact service continuity.

"The data center world runs on uptime," said Jonatan Hongisto, Director of Industrial Measurements' Service Portfolio at Vaisala. "Even a minor measurement drift in humidity or temperature can cascade into cooling failures, hardware damage, or downtime. The cost of getting it wrong can be significant.

As facilities grow, operators need a structured way to manage measurement performance and lifecycle support across hundreds of instruments. Accurate measurements are business-critical, but maintaining them consistently over time has become increasingly difficult as data centers grow in size and complexity."

Vaisala Care for Data Centers is designed to provide a structured approach to calibration, verification, and long-term measurement support across the facility lifecycle.

The portfolio includes three offerings: Vaisala Care, Vaisala Care+, and Vaisala Commissioning Care, with service options ranging from accredited calibration, replacement probe pools, and expert support to on-site services and commissioning-phase calibration documentation. Unlike traditional service models focused on individual instruments, agreed verification scopes may also include selected third-party measurement devices, helping operators simplify measurement management across the facility.

Vaisala's new service portfolio helps operators maintain measurement accuracy, operational reliability, and uptime throughout the lifecycle of their measurement systems. (Courtesy: Vaisala)

Vaisala has released a downloadable eBook that addresses wind Lidar questions. (Courtesy: Vaisala)

"We're moving beyond individual service transactions toward a long-term partnership in helping customers maintain measurement performance," Hongisto said.

The portfolio includes remote and on-site service options as well as commissioning-phase calibration and handover documentation for new facilities, allowing operators to choose the service model that best fits their operational requirements.

MORE INFO www.vaisala.com/en/services/vaisala-care/vaisala-care-data-centers

INNOVATION

Vaisala eBook covers new, innovative algorithms

Since wind Lidar has been part of wind resource assessment, two common questions have persisted: Can Lidar measure turbulence intensity accurately enough to replace a met mast? And how much usable data will a campaign recover at sites with clean air, fog, or heavy precipitation?

Two algorithms in Vaisala's Compass Renewable now address these questions directly. WindCube Pure

TI provides physics-based turbulence intensity reconstruction, while Availability Booster combines optimized wind-field reconstruction with deep learning-based filtering to maximize data recovery.

Both run on data the WindCube has already collected, including completed campaigns and reducing dependence on dedicated TI met masts, along with the permitting and site access they require. The eBook covers what's behind each algorithm, what validation across 48 sites and 104 WindCube units shows, and why turbine OEMs and independent consultants are now putting them to work.

MORE INFO www.vaisala.com/en/ebook/introducing-availability-booster-and-wind-cube-pure-ti

MAINTENANCE

Nexxis Technology acquires BladeBUG robotics company

Nexxis Technology has completed the acquisition of BladeBUG, a U.K.-based robotics company developing advanced solutions for wind-turbine inspection and maintenance. The acquisition expands the company's capabilities in the global wind and renewable-energy markets while bringing together complementary robotic technologies, engineering expertise and customer networks.

"BladeBUG was founded to make wind-turbine inspection and maintenance safer, faster, and more effective," said Chris Cieslak, founder and CEO of BladeBUG. "Joining Nexxis gives our team access to complementary technology, global market reach, and additional resources to accelerate our development, go-to-market strategy,and ability to scale. We are excited about what our teams can achieve together for customers and the wider renewable-energy industry." BladeBUG has developed a suction-based robotic platform designed to move across wind-turbine blades and other non-ferrous or composite surfaces. Nexxis Technology's Magneto robotic platform uses electromagnetic adhesion to operate on ferrous metal structures.

Bringing these capabilities together will allow the combined business to address a wider range of surfaces, assets, and operating environments. Nexxis also plans to integrate its modular system architecture, artificial intelligence, machine vision, and data capabilities into future product development. The acquisition will strengthen the companies' ability to deliver robotic solutions that improve inspection quality, reduce human exposure to hazardous work, and provide better data for asset owners and operators.

The combined engineering teams will explore opportunities to connect BladeBUG's suction-based adhesion technology with Nexxis' Magneto electromagnetic technology and modular robotic architecture. This approach is intended to support robotic inspection across ferrous, non-ferrous, and composite surfaces, creating broader applications within wind energy and other asset-intensive industries.

"The acquisition of BladeBUG accelerates the growth of Nexxis and extends our technology into a wider range of industries and applications," said Jason De Silveira, founder and CEO of Nexxis Technology. "By bringing together BladeBUG's suction technology, our Magneto electromagnetic platform, modular architecture, and AI capabilities, we can address more surfaces and solve more complex inspection challenges." "Our purpose remains clear: to improve the inspection of critical assets, increase safety, and reduce operational risk," he said. "We also want to make reliable data the foundation for better-informed maintenance decisions, improved asset performance and longer asset life."

BladeBUG's London office will become an important part of Nexxis Technology's U.K. and European presence. It will support regional custom-

Nexxis Technology's acquisition of BladeBUG, a U.K.-based robotics company developing advanced solutions for wind turbine inspection and maintenance, expands the company's capabilities in the global wind and renewable-energy markets. (Courtesy: Nexxis)

ers, partnerships, engineering collaboration, and future commercial growth.

For customers, the acquisition is expected to provide access to a broader range of technologies and stronger engineering support. Both companies will continue to support existing customers, projects and commitments while the integration program progresses.

MORE INFO www.bladebug.co.uk

MANUFACTURING

CS Wind Offshore selects CNC Onsite for German wind farm

Offshore wind foundation manufacturer CS WIND Offshore has begun operating a custom-built, automated milling machine from Danish machining expert CNC Onsite at its Aalborg facility in Denmark to create high-precision cable penetrations in transition pieces destined for offshore wind farms. This process ensures cables powering external workspace lighting and platform cranes can be sealed with maximum reliability.

Delivering sub-millimeter precision, CNC Onsite's new magnet-mounted gantry machine replaces manual cutting with a CNC-controlled milling machine that produces clean-cut penetration holes. These six cable holes per transition piece require precise edges to allow for the flawless sealing required around the power cables, a requirement in harsh ocean environments. CS WIND Offshore ordered the customized gantry machine to also mill the 12 pressure relief holes per transition piece, holes designed to relieve pressure and prevent structural warping under rough sea conditions.

"We required a tolerance of one millimeter to eliminate micro-gaps and completely isolate the internal electrical routing," said Flemming Smidt Pedersen, senior manager, production engineering, at CS WIND Offshore. "At sea, this watertight integrity is absolute." The cables passing through these points power the platform cranes tasked with hoisting critical spare parts to the turbines, as well as the signal lights that illuminate identification numbers on each wind turbine.

"Surpassing our target to achieve a tolerance of just 0.3 millimeters through this entirely dust-free process has allowed us to secure this vital infrastructure while maintaining a cleaner, optimized manufacturing environment," Pedersen said.

With a height of 2 meters, a length of 3.6 meters, and a width of 2.3 meters, CNC Onsite's 4-axis gantry machine was developed at the company's headquarters in Vejle, Denmark, in a workshop dedicated to producing customized, high-precision solutions.

"We specially developed the mobile gantry milling system to deliver consistent, high-precision results on steel components," said says Søren Kellenberger, CEO of CNC Onsite. "These parts are massive and virtually impossible to move into a standard machine. Therefore, we bring the machine to the workpiece instead. This project was a perfect fit for us, as our specialty is bringing precision machining directly to the component." Leveraging CNC Onsite's background in maritime and energy projects, the company designed the mobile gantry machine to produce cable transits in a single automated pass, completely eliminating the need for manual flame-cutting and grinding.

The company also developed a proprietary magnetic fastening mechanism to provide a stable, vibration-free foundation without the need for traditional, invasive clamping. By using powerful electromagnets, the machine locks directly onto the curved structure of the transition piece with high clamping force, yet leaves the high-grade steel surface completely unmarked. This approach is a significant benefit for transition piece manufacturers, as it prevents surface scarring and eliminates rework.

To accommodate the diagonal routing of the cables through the structure, the penetration wall requires a 45-degree angle. CNC Onsite easily meets this specification with its adjustable machining angle ranging from 28 to 90 degrees. For this specific scope of work, the penetration holes measure 180 millimeters by 350 millimeters. However, the gantry machine is highly versatile, capable of processing openings ranging from minor 50-millimeter-diameter utility holes up to large-scale structural oval penetrations measuring 2,575 millimeters by 550 millimeters.

The 4.8-ton mobile machine manages significant geometric challenges in the manufacturing facility, where each 370-ton transition piece spans 7.8 meters in diameter and must be rotated on rollers to align the cutting zones. Equipped with an adjustable wheeled maneuvering setup, the machine tracks the cylinder's rotation, minimizing manual handling during repositioning.

"This integration of advanced gantry engineering and sub-millimeter precision confirms that manufacturing of large complex steel structures can be optimized to meet the increasingly stringent technical standards of the global offshore energy sector," Kellenberger said. Headquartered in Vejle, Denmark, CNC Onsite designs and delivers high-precision mobile machining for wind turbines, including offshore foundations. Machinery built by CNC Onsite is designed to be flexible using its proprietary "building blocks" approach, meaning machinery can be built to match a range of tasks.

Founded in 2012, CNC Onsite serves

the onshore and offshore wind-energy sector, delivering standard solutions such as machining of large-diameter steel flanges and blade root ends, along with specialized repair services covering yaw rings, blade root inserts, rotor locks, generator shafts, bearing housings, and threaded holes. Removal and replacement of worn and broken bolts round off the offering. The company operates with ISO 9001, ISO 14001, and ISO 45001 certifications. CNC Onsite A/S is a privately held Danish company.

MORE INFO www.cnc-onsite.com

MANUFACTURING

Flender launches generator production site in India

Flender recently announced the inauguration of an additional generator production site in India. Renewable energy depends on powerful wind turbines — and at the core of every turbine is the drivetrain, with the generator transforming rotational motion into electricity for the grid. The new production site in Chennai, Tamil Nadu, reinforces the value chain of Flender's generator business and expands its global presence.

As a leading system supplier to the global wind market, Flender — through its Winergy brand — brings together comprehensive expertise across the entire drivetrain, offering gearboxes, generators, direct drive segments, couplings, and multi-brand drivetrain services.

This strategic investment is a significant step in Flender's initiative to expand its wind business in India. At the same time, the company continues to localize the supply chain, including integrated winding operations, to enhance manufacturing capacity closer to its customers. By expanding its presence in India, Flender aims to improve responsiveness, reduce lead times, and further reinforce its reputation as a reliable and trusted partner for the wind industry in India.

"The inauguration of our new generator site is an important milestone in the growth journey of our Winergy business in India," said Joerg Sieber, VP Wind Generators at Flender. "It reinforces our long-term commitment to our customers and to the whole wind industry."

"The new facility will support the increasing demand for wind-power solutions, while also contributing to local industrial development and skilled employment," said Vinod Shetty, Country CEO of Flender India. "This investment continues the successful localization efforts at our Indian locations and underscores Flender's broader commitment under the Winergy brand to accelerate deployment of renewable energy."

MORE INFO www.flender.com

WHY CONNECTION TECHNOLOGY IS FLOATING WIND'S NEXT HURDLE

Configurability is central to how Squid is deployed. Rather than dictating the design of a project's mooring system or cable specification, it is designed to work within them. (Courtesy: Encomara)

As floating wind moves from pilot projects to commercial-scale deployment, how the sector designs for disconnection and reconnection will shape the cost and availability of these assets in the future.

By DUNCAN BLACK

As floating wind moves into commercial-scale deployment, developers must consider not only how turbines are installed, but how moorings, cables, and major components will be managed throughout a 25-year design life. Addressing this challenge is increasingly seen as a design question rather than a maintenance afterthought — one that's beginning to reshape how the sector approaches the connection system.

The global market is projected to grow from S3.16 billion in 2026 to S25.4 billion by 2031, at a CAGR of 51.7 percent [1]. Globally, the sector is moving from the pilot to commercial phase, underpinned by policy to support new projects. Europe is a pioneer in this sector, with Scotland home to two operational farms — Hywind and Kincardine — while first power was delivered from the EFGL farm in France in May 2026.

Global national FOW targets currently exceed 40 GW, with active leasing and licensing rounds under way in the U.K., Norway, France, China, South Korea, the Philippines, and Australia. France's AO10 tender, launched in June 2026, is targeting roughly 5 GW of floating capacity in the second half of this year, the largest floating procurement event launched globally to date, while the U.K.'s AR8 round includes two eligible floating projects within a 28 GW pipeline.

Turning this pipeline into deployed capacity means proving designs at commercial scale, not just as single demonstrators, and keeping them running reliably over a 25-year asset life.

Despite these successes, the sector is grappling with challenges to ensure projects secure a financially viable route to market. An essential part of the business and commercial model for any floating wind development is the strategy for major component repair (MCR) and potential repowering in late life. This strategy must cover not just the nacelle, but the entire floating system, including tower, foundation, mooring, and cable components plus ancillaries. Developers are increasingly seeking out innovative solutions to support these challenges, ensuring their projects remain insurable and financially viable over the full asset lifecycle — and in turn, lowering the Levelized Cost of Energy (LCOE).

REDUCING COST THROUGH INTEGRATED DESIGN APPROACHES

Cable and mooring installation is typically carried out as two distinct operations, each with its own vessel spread, specialist contractor, and installation sequence. Mooring lines are pre-laid and pre-tensioned on the seabed, often before the floating turbine arrives on site, then hooked up once the turbine is towed into position. Power cables are installed separately, usually via a dedicated cable-lay vessel, and connected to the turbine and the export system once moorings

The Squid system integrates a floating turbine's mooring lines, power cables, and all subsea connectors into a single deployable unit. (Courtesy: Encomara)

are in place. This sequential, siloed approach mirrors how the two systems are designed and, later, how they're maintained — setting up the same disconnection and reconnection challenges seen in MCR operations.

Tow to Port (T2P) is the current accepted process for MCR strategies. In this practice, the turbine is disconnected from its moorings and electrical cables and towed to port to allow the component changeout to take place quayside by an onshore crane, before being returned offshore. However, this method carries significant operational limitations. According to DNV, subsea cables account for up to 80 percent of insurance claims in the offshore wind sector. Risks include natural hazards and dragged anchors.

When mooring lines and power cables are disconnected, they are typically disconnected independently and controllably lowered to wet-storage on the seabed, with loose lines often tangling on the seabed. Reconnecting them means locating and hauling each one back up in turn. Once the equipment is lowered, the chances of damage rise sharply, and repairing a subsea power cable is not cheap. This also creates a knock-on production problem too, one specific to

A recent study by OSSIAN placed the estimated savings of using the Squid system at 1 billion pounds per gigawatt. (Courtesy: Encomara)

Suspended mid-water, the Squid buoy system integrates power cables and moorings in a wave profile, a similar configuration to that when connected, ensuring high operability and reduced risk of damage to hardware and the seabed. (Courtesy: Encomara)

how wind farms are wired. Turbines on a shared export cable are strung together, so disconnecting one for maintenance can break the circuit for every turbine further down the line, not just the one being serviced. It is not unlike old-style Christmas tree lights, where a single failed bulb took the whole string down, before LED circuits learned to bypass the fault and keep the rest lit.

Part of the reason this issue has persisted is structural rather than technical. Mooring engineers and cable engineers have historically worked in separate silos, each designing to their own brief. Systems have rarely been built with disconnection and reconnection in mind from the outset, because no one owned that problem end-to-end.

If future projects are to reduce maintenance costs and improve availability, disconnection and reconnection can no longer be treated as an afterthought. Instead, they need to be designed into the system from the outset. This shift in thinking is now beginning to emerge, with new integrated approaches aiming to manage moorings and power cables as a single engineered system rather than two separate disciplines. Addressing this means adopting an approach, such as MCR and T2P, and including it in project design specifications as early as possible, rather than treating them as a later-stage fix. The same thinking benefits hook-up operations, too, since reconnection largely mirrors the initial process, along with how insurers view Construction All Risks (CAR) and Delay in Start Up (DSU) cover.

A SINGLE SYSTEM FOR MOORINGS AND CABLES

Disconnectable turret buoy technology has long been used in oil and gas projects, enabling cables and mooring lines to converge through a buoy connected to a ship, so the vessel can swivel free. Recognizing the resemblance, Encomara drew on these principles to develop the Squid connection solution. This system has been developed around that lifecycle challenge, reducing the complexity and offshore exposure associated with connection, disconnection, and T2P operations, while supporting the risk reduction increasingly important to developers, operators, and insurers. Following significant research and development investment, the innovative technology — which has received product design assessment from the American Bureau of Shipping — allows for the pre-installation and pre-commissioning of all mooring and power cables.

The Squid system integrates a floating turbine's mooring lines, power cables, and all subsea connectors into a single deployable unit, allowing both to be installed mid-water before the turbine arrives on site. By combining the associated marine hardware into one unit, it provides a simplified "Plug to Power" (P2P) capability. This results in accelerated installation and cuts both the capital cost and the time needed to get a floating turbine connected, lowering the LCOE by up to 20 percent.

Suspended mid-water, the Squid buoy system integrates power cables and moorings in a wave profile, a similar configuration to that when connected, ensuring high operability and reduced risk of damage to hardware and the seabed. It sits inline where cables run through the base of the floating hull, with mooring lines connecting via short secondary "squid lines," while the main cables pass through it as they would through the hull directly. Once locked into the hull, Squid has no in-service mooring load path and does not swivel, allowing developers to pre-install 100 percent of subsea and marine hardware in advance of FOWT deployment and

AD INDEX

Castrol ..... BC

ColdSnap Towers 25

Dellner Wind Solutions ..... IBC

Elevator Industry Work Preservation Fund 1

H&N Wind 27

Malloy Electric 23

Oceantic Network 13

Stahlwille Tools LLC 34

Texas Controls ..... IFC

Vertical Supply Group 29

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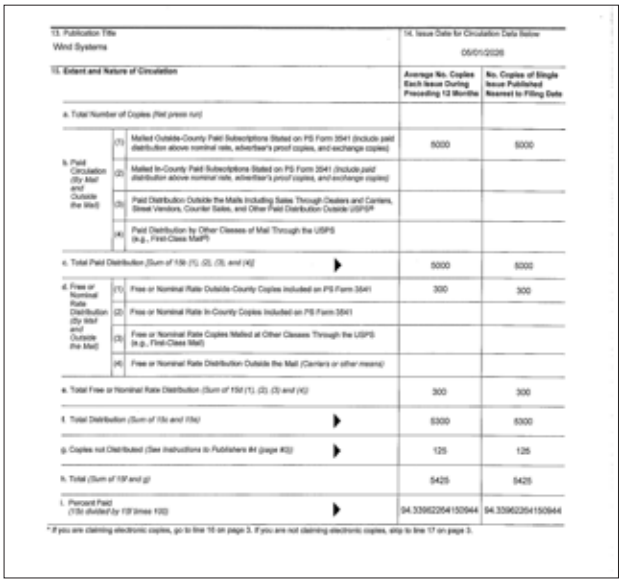

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maximize pre-commissioning, similar to fixed wind, prior to the turbine's arrival.

The same capability applies at the other end of a turbine's life, when an asset is disconnected for T2P maintenance or repowering. Rather than dropping cables and moorings separately to the seabed, where they can tangle or be damaged, the buoy releases them together and holds them just below the surface, ready for quick reconnection when the floater returns — keeping power and communication continuous. Reconnection reverses the same process. By reducing the time a turbine spends disconnected, the system also increases operational uptime, an important consideration given that turbines sharing an export cable can lose production collectively while any one of them is offline.

This uptime advantage depends on being able to connect and disconnect turbines in the first place, and this is where the buoy-based method's weather tolerance matters most. Because the connection is made at the buoy rather than directly at the vessel, it can be carried out in higher wave heights than conventional vessel-based methods allow, widening the installable weather window significantly. This benefits T2P operations as much as initial installation, since reconnecting a returning turbine faces the same weather constraints as connecting one for the first time. Estimated savings are 2 million to 6 million pounds CAPEX per FOWT and approximately 9 million to 18 million pounds per T2P event in OPEX/revenue impact, depending on the scenario.

A recent study by OSSIAN, funded by Scottish Enterprise, placed the estimated savings of using the Squid system at 1 billion pounds per gigawatt compared to traditional methods as fewer vessel days are required to perform operations using this system. This approach also increases safety, reduces operational costs, and significantly decreases project-associated emissions.

DESIGNING FOR DISCONNECTION

Configurability is central to how Squid is deployed. Rather than dictating the design of a project's mooring system or cable specification, it is designed to work within them, whatever hull, mooring configuration, or connector type a developer has already selected. No two floating wind projects are the same, and equipment varies between developers and installation contractors. A solution that assumes a single configuration would only ever suit a fraction of the market.

This flexibility reveals a broader point about where these decisions are made in a project's lifecycle. Floating wind developments typically progress through conceptual design, pre-front-end engineering and front-end engineering design (FEED) phases, with major equipment contracts placed once FEED concludes. Decisions taken at this stage on hull type, mooring configuration, and cable routing shape what is and isn't possible for the rest of the asset's life.

A disconnection strategy bolted on after these choices are locked in has far less room to work with than one considered alongside them.

This is the wider case for building MCR and repowering considerations into project design from the outset. A system built to simplify disconnection only delivers its full value if that requirement is planned for at the earliest stages, alongside mooring and cable specification, rather than retrofitted once a project's engineering is already fixed.

For developers weighing up the total cost of ownership across an asset's operational life, that means treating disconnection and reconnection capability as a design input from FEED onward, not a problem to be solved when a turbine first needs to come offline.

The projects best placed to manage MCR and repowering costs will likely be those that treated the question as a design parameter from day one, not those that revisited it once construction was already under way. As floating wind moves from pilot projects to commercial-scale deployment, how the sector designs for disconnection and reconnection today will shape the cost and availability of these assets for decades to come.

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[1] Floating Offshore Wind Market Report 2026-2031 [375 Page & 150 Table].

ABOUT THE AUTHOR

Duncan Black is chief design engineer with Encomara.

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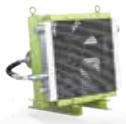

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5 PUMP UNIT FOR GENERATOR COOLING

6 PUMP UNIT FOR GEARBOX COOLING

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9 FLEXIBLE COUPLING

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