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Blades ◤ Gearboxes ◤ Repowering

HIGH-VOLUME SHREDDING OF OVERSIZE TURBINE BLADES NOW POSSIBLE

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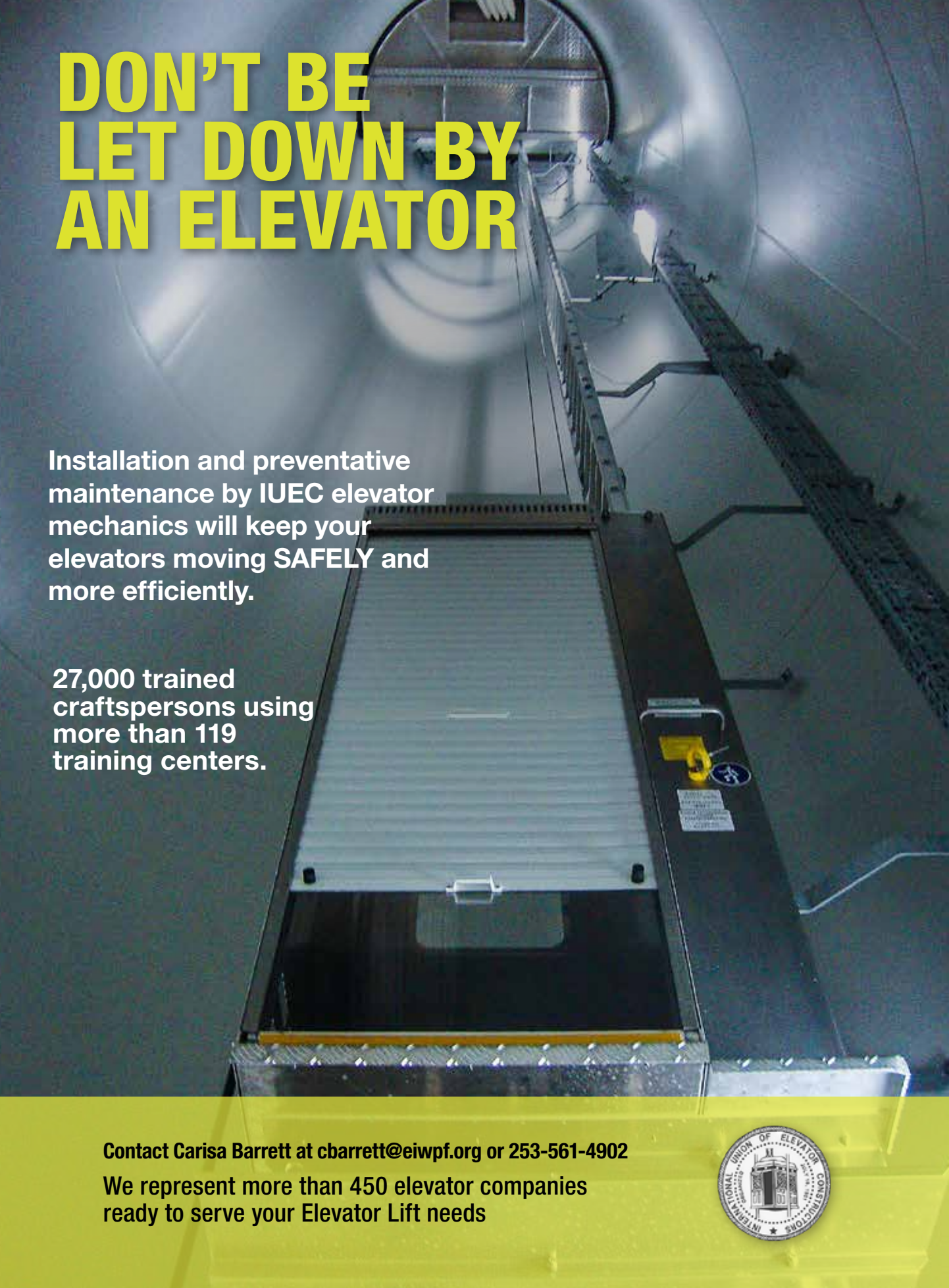
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With a thriving ecosystem of innovation tailor-made to help companies achieve their goals, Ireland is an environment primed to support continued business recovery and continued momentum in sustainability.

TAILWINDS

THE BUSINESS OF WIND

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FROM THE EDITOR

Exploring blades, gearboxes, and repowering

With an ambitious plan to ensure the U.S. achieves a 100 percent clean-energy economy and reach net-zero emissions by or before 2050, it's important that we all do our part to ensure this becomes a reality sooner rather than later. Not only might the fate of the planet depend on it, but it just makes good business sense.

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, gearboxes, and repowering — vital subjects that run the gamut from the micro to the macro.

Beginning with blades, as many wind turbines inch closer to their end of life, their massive blades can't just be thrown into the nearest dumpster.

Breaking down the giant composite fiberglass blades can become quite the challenge, but, in our first inFocus article, John Neuens with BCA Industries discusses how high-volume shredding of oversize turbine blades is now possible.

Being a technophile, I always enjoy the opportunity to share with you some highly technical articles about wind whenever I have the chance.

In our second inFocus article, Yi Guo and Jonathan Keller share their insights on formulating load-sharing behavior in epicyclic gears for wind turbines, and how that has been reformulated for turbine gearboxes. It's a deep, deep dive into the literal nuts and bolts of this issue. I hope our engineering readers will appreciate it — and learn from it.

When it comes to repowering wind assets, it's important to keep up with market needs. In our third inFocus article, Muhammad Malik, CEO and founder of NeuerEnergy, discusses how wind-energy providers can scale their operations in order to keep pace with the growing demand.

And be sure and check out our Conversation with Lium's Joseph Triepke, where he talks with *Wind Systems* about the importance of a robust supply chain for the burgeoning offshore wind industry.

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

As always, thanks for reading!

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Giving Wind Direction
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ACP launches ads in seven states and D.C. on infrastructure bill

From ACP

As Congress continues work to pass historic infrastructure packages, the American Clean Power Association (ACP) recently launched the next phase of its Powering American Jobs campaign with advertisements in seven states and Washington, D.C. The ads feature clean-energy workers and urge Congress to pass infrastructure legislation with smart and predictable incentives that will boost investments and create additional jobs in the industry.

"Congress has a once-in-a-generation opportunity to update our country's aging infrastructure, much of it battered by extreme weather events, to ensure a clean energy future for all Americans. The adoption of stable policies will drive investment so our industry can accelerate the delivery of projects creates more good-paying jobs and helps the U.S. meet emissions reduction targets," said Heather Zichal, CEO of American Clean Power. "Industry momentum combined with supportive policies and regulations could deliver over 1 million clean energy jobs by 2030 across the country."

The 30-second video ads will run while Congress considers these important job creating investments in a clean energy future.

View the new American Clean Power national ad at bit.ly/3ttNSuF

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

DIRECTION

THE FUTURE OF WIND

The E1000 system can switch from personnel to cargo transfer mode in less than a minute. (Courtesy: Ampelmann)

Ampelmann signs 13 contracts in European offshore wind

Dutch offshore wind access company Ampelmann signed 13 contracts in 2021 to provide motion-compensated gangway solutions for personnel and cargo transfer in Europe.

"Securing these projects has brought us new opportunities to deliver the highest level of safety to offshore operations," said Bob Rollerman, business developer for Europe at Ampelmann.

Ampelmann will use its A-type and E1000 systems for all 13 campaigns. Two will use the company's A-hoist, an innovation that allows the A-type to efficiently and safely lift and transfer up to 240kg of cargo.

For larger cargo operations, Ampelmann is using the E1000, which can transfer loads up to 1 ton, as well as compensate for vessels' motions in the high seas.

"Safety and efficiency are at the core of what we do at Ampelmann and the E1000 delivers on both. It significantly improves the efficiency of our client's operations, with its ability to switch between cargo and personnel transfer in less than a minute and with the push of a button," Rollerman said.

One of the projects is the company's first in France, supporting the installation of a wind farm's foundation.

"Every commissioning operation in offshore wind is a step in the right direction and entering new geographical areas in that market is particularly exciting," Rollerman said.

Apart from the installation and commissioning of wind farms, Ampelmann's systems are also supporting multiple maintenance operations. Most of the contracts are with returning customers.

The company has introduced Insights, its data-driven platform that gives clients a detailed look into their day-to-day operations, including transfer numbers, performance, and workability forecasts based on sea and weather conditions.

According to some of the latest data, Ampelmann has enabled the safe transfer of more than 22,000 people and close to 1.5 million kg of cargo so far in the new projects.

MORE INFO www.ampelmann.nl

The British Consulate-General in Boston, Massachusetts, commissioned a U.S. offshore wind industry analysis and found opportunities available for U.K. companies to enter the growing U.S. market. (Courtesy: Xodus)

Study: Opportunities abound for U.K. in U.S. offshore wind

The British Consulate-General in Boston, Mass. commissioned a US offshore wind industry analysis and found opportunities available for U.K. companies to enter the growing U.S. market. The analysis by global consultancy firm Xodus researched the local and regional supply chain around Massachusetts and carried out an assessment and gap analysis for Hampton Roads and the southern Virginia region.

"I'm delighted that the Xodus analysis has identified so many opportunities for U.K. companies to support the growing US offshore wind industry with their experience and expertise," said Dr. Peter Abbott OBE, New England's British consul general.

"There is a significant benefit from first mover advantage in the developing the U.S. supply chain. The ambitious federal offshore wind capacity targets are creating project demand to warrant a long-term U.S. supply chain. There are significant export opportunities for U.K. supply chain companies throughout the offshore wind project phases, however these appear to be strongest in project development, construction and O&M services where U.K. companies can offer both established and innovative solutions based on their experience supporting domestic offshore wind projects," said Hillary Bright, U.S. VP for Renewables at Xodus.

All contracted offshore wind farms under development in the US are located on the east coast. It is anticipated that $80 billion in CAPEX expenditures will be made in developing

About 14,000 wind-turbine blades are expected to reach the end of their usable life within the next three years. (Courtesy: Net Zero Technology Centre)

the industry by 2030, and that up to 80,000 jobs will be created. With the recent Record of Decision granted to Vineyard Wind I, the first commercial scale U.S. offshore wind farm, it is anticipated that the approval of the other projects in the pipeline will accelerate.

There is a push to develop local content in the U.S. offshore wind industry, and states are eager to attract industries that support all phases of wind farm development, construction and operations. It is expected that these industries will cluster around eastern U.S. ports, and the growth of a supporting supply chain will quickly follow.

"A critical consideration for companies looking to enter the U.S. offshore wind market is where to establish a presence. Supply chain clusters in the U.K. have been seen to support the development of unique skills and technology solutions in the offshore wind sector," said Hannah Webb, trade officer of offshore wind and clean energy for the U.K. Department for International Trade.

"With the intel that Xodus is providing, we are working to understand the location and strengths of potential US supply chain hubs and strategizing successful market entry for companies from the Northern Powerhouse, U.K. These companies have significant offshore wind development experience in the U.K., Europe, and even Asia, to offer to the US market and we are building impactful partnerships around the clusters and ports that Xodus has identified along the east coast of the U.S.," Webb added.

MORE INFO www.xodusgroup.com

U.K. could become leader in wind-turbine blade recycling

The wind sector offers a huge opportunity for the U.K. to become a global leader in wind turbine blade recycling if a cross-industry approach is taken, according to the Energy Transition Alliance, a collaboration between the Net Zero Technology Centre and Offshore Renewable Energy (ORE) Catapult.

The alliance's report highlighted that around 14,000 wind turbine blades are expected to reach the end of their usable life within the next three years. By 2023, an estimate of up to 50,000 tons of composite material could be recovered and recycled for a variety of re-use applications. By driving forward a better understanding of the circular economy, the possibility of disposal in landfill or incineration can be avoided and liability reduced.

While there has been significant investment within the renewable energy sector to improve installation, operations and maintenance, the focus is shifting to sustainable end-of-life management as the first offshore wind farms approach decommissioning in the next 10 years.

Over the next three decades the industry faces significant growth in the scale of turbines expected to be decommissioned. Solutions are being sought for lifetime extension and more sustainable end-of-life management, such as repowering and circular economy practices.

This new report identifies five areas that the sector must address to achieve a more circular economic model: Encouraging use of materials more compatible to recycling; developing processes that allow cheaper, easier recover of materials during decommissioning; creating pilot projects industry-wide for new recycling methods and technologies; establishing a supply chain for recycled material; and educating the marketplace about opportunities for wind turbines' recycled materials.

"The report illustrates what can be achieved in this industry if we can develop a collaborative approach that involves all sectors striving for sustainable decommissioning. With input from manufacturers through to end users, we can reinvent how wind turbines are recycled," said Pamela Lomoro, project manager at the Net Zero Technology Centre.

While wind turbines are widely expected to be up to 90 per cent recyclable, the blades, which are made from composite layers of stiff carbon or glass fibers in a resin matrix, are notoriously challenging to reclaim and reprocess, and remain the most significant hurdle to achieving full wind turbine recyclability.

"The innovation challenge to create a circular economy within the wind industry is vast, but hugely exciting. This is a significant opportunity for the supply chain, given the huge volume of decommissioning and industry expansion ahead," said Lorna Bennet, ORE Catapult project lead.

"The best solution is likely to come from a multi-sector approach because of the economies of scale required to create a market for recycled material. Likewise, the drive for better practices in recycling techniques and to develop better research and technologies will come from innovation and cross-industry collaboration," Bennet said.

MORE INFO www.netzerotc.com

Maritime Academy trains workers for jobs in clean energy

The Massachusetts Maritime Academy (MMA) is training workers who will build the wind farms that will provide clean energy to the northeast U.S.

"It's a fact that the clean energy industry is growing, and we are taking steps to be involved in this unique opportunity," said Rear Admiral Francis X. McDonald, USMS, president of the Massachusetts Maritime Academy.

"One of the most important ways we can contribute is by training the men and women who will be on the front lines of this emerging industry," McDonald said.

"The opportunity to work in the clean-energy industry is great for our members," said Dave Borrus, Pile Drivers and Divers Local 56 business manager. (Courtesy: Massachusetts Maritime Academy)

The Massachusetts Clean Energy Center provided funding in 2018 for MMA to build its Global Wind Organization training facility at the Maritime Center for Responsibility Energy. The center consists of a waterfront crew transfer training facility, a 25-foot crew transfer training vessel, and a facility for training in working at height. MMA began in 2019 offering GWO basic safety training, becoming the first in the U.S. to offer all five modules of GWO basic safety training for offshore wind.

The course includes modules about working at height, first aid, fire awareness, manual handlings, and sea survival. Instructors' goals are to make workers familiar with wind industry work hazards and how to deal with them.

Three wind farms are in various stages of development in the Atlantic Ocean, about 20 miles south of Nantucket and Martha's Vineyard. Those farms' developers require the basic safety training course.

"MMA has the experience to deliver this critical course, ensuring quality training to the people who will be out on open water building the wind turbines," said Jenni Lewis, MD RelyOn Nutec Gulf of Mexico.

Members of Pile Drivers and Divers Local 56, the marine construction local of the North Atlantic States Carpenters Union, are taking advantage of the course. "This training is critical to our members," said Dave Borrus, business manager of Pile Drivers & Divers Local 56. "The opportunity to work in the clean energy industry is great for our members but there are occupational risks, too. Safety must be at the forefront of each member's mind," said Borrus.

The Massachusetts Clean Energy Center is sponsoring Local 56 members' participation with a $100,000 workforce development grant.

Training consists of both classroom and practical exercises. Participants acquire knowledge and confidence by learning the practical skills they need through practice. Students learn the proper use of personal protective equipment, emergency equipment, and procedures with the end result being able to appropriately respond in the event of an emergency.

Capt. Mike Burns, executive director of the Academy's MCRE, praised the maritime academy's training.

"Every group that has gone through the training has been exceptional. The participants are highly skilled professionals who understand the importance of safety in this industry. It's our honor to help them prepare for the next phase in their careers," he said.

MORE INFO www.maritime.edu

HIGH-VOLUME SHREDDING OF OVERSIZE TURBINE BLADES NOW POSSIBLE

A new generation of advanced shredding technology is ready to help composites recyclers reliably shred even the toughest scrap materials, including wind-turbine blades, to chips at high volumes using unique advances in hydraulic systems. (Courtesy: BCA Industries)

Cost-effective, innovative shredder designs eliminate catastrophic breakdowns, production downtime by upgrading points of vulnerability and enabling simultaneous shredding and chipping.

By JOHN NEUENS

In the wind-power industry, when turbines are eventually decommissioned or wind farms upgraded in a process called repowering, wind-turbine blades must either be disposed of or recycled.

However, giant composite fiberglass wind-turbine blades, which can be up to 80 feet long and weigh many tons, have been challenging to shred and recycle. Even after the blades are broken or cut into smaller chunks, the pieces can be too large for most feed chambers. Also, the thickness, brittle nature, and density of the composite parts are extremely challenging, as well as controlling the dust generated from shredding them.

With wind energy rapidly expanding, thousands of such distressed wind-turbine blades will need to be taken out of commission and recycled, increasing shredding volumes.

On top of this, such thick, dense composites can force maintenance issues in most shredding equipment, causing costly, lengthy breakdowns. In fact, shredding tough fiberglass, Kevlar, or other composites of any large forms down to specific, recyclable sizes often requires a primary and a number of secondary shredders in multiple step reduction while handling the dust collection and filtration.

Now, however, a new generation of advanced shredding technology can help composites recyclers reliably shred wind-turbine blades to chips at high volumes using unique advances in hydraulic systems.

VULNERABLE POINTS

The problem is that traditional large capacity shredders have points of vulnerability such as knives, shafts, bearings, and hydraulics not truly designed for such loads or volumes. This can result in breakdowns and lost production downtime with long lead times for critical replacement parts and rebuilds.

The cumbersome process of shredding, screening, and grinding composites and materials to size with different equipment in separate operations has also traditionally been a bottleneck to processing. Screening is often a slower process than shredding.

An innovative shredder technology from BCA Industries enables recyclers to simultaneously shred and chip in portable or stationary systems, eliminating downtime, speeding production, and reducing costs. (Courtesy: BCA Industries)

In response, to ensure high production and reliability in such applications, industry innovators have developed high-volume, high-torque shredders with large chambers that enable efficient reduction of oversize turbine blades pieces.

With knife geometry modified to properly "grab" the material and feed it well in horizontal or vertical applications, the high torque, low speed equipment (like dual shaft shredders) minimizes dust generation as well as breakdowns, so the equipment is durable enough to last decades.

Getting to the root of the processing bottleneck, a new shredder knife technology is also enabling composites recyclers to simultaneously shred, chip, and size in portable or stationary systems, further speeding production and reducing processing costs.

CONVENTIONAL SHREDDER LIMITATIONS

For truly high-volume composites recycling operations, the size of the shredder can restrict production flow if it is not large enough to accept oversized scrap and materials. Hydraulic shredders operating at a single RPM, using a single rotary piston or gear pump, also never maximize throughput regardless of load.

The lack of robust construction, designed for reducing tough materials at high-volume, inevitably leads to breakdowns and unscheduled downtime for repair and replacement.

Typically, shredder companies use 4,140 knives, traditional hard-face welding or even tool steel for their systems, but inferior knives increase recyclers' top maintenance cost — knife rebuilds.

A host of other shredder design vulnerabilities can lead to catastrophic failures if not addressed:

- Expensive shaft washout, due to undersized material along with poor shaft or clamping nut design, as well as old-style hex shafts, can allow stack loosening during operation.
- Bearing failure, caused by contamination, often occurs when bearing seals and shaft armor insufficiently protect against shredding chamber compression forces.

Perhaps the most consequential point of failure can occur when shredder manufacturers build hydraulic power supplies using a single but very expensive hydraulic pump or motor, which can cost up to $90,000 to replace with lead times of 12-plus weeks, resulting in excessive downtime.

REINVENTING HIGH-VOLUME RECYCLING

To help high-volume composites recyclers dramatically and cost-effectively improve their production with minimal downtime, industry innovators have redesigned and modernized shredder systems, which have not been substantially updated in generations.

One example, a customizable, high volume shredder is designed for the toughest wind-turbine applications involving composites in both stationary and portable units.

With 24-inch diameter hard-faced knives using a base AR-500 alloy, 55-inch to 72-inch by 44-inch cutting chambers, and eight-inch 4130 Chromoly steel shafts, the unit can quickly reduce even the largest wind-turbine composites scrap. With 24,000 to 38,000 pounds total gross weight (not including power supply), it is designed to shred 15 to 35 tons of composites or dense materials an hour with 179,000 foot-pounds of torque per knife.

When even more throughput is required, it can be rated up to 800 HP, and use dual cutting chambers. To maximize high-torque throughput and efficiency, it uses a pressure compensated variable displacement pump that allows the

A new generation of advanced shredding technology, including a unit called "The Beast," helps recyclers reliably shred even the toughest materials into chips at high volumes using unique advances in hydraulic systems. (Courtesy: BCA Industries)

RPM to increase and decrease based on load.

The unit's design addresses the vulnerabilities of conventional shredders by using inexpensive cluster drive system of eight small hydraulic motors that create redundancy in the power supply that eliminates much of the possible downtime. These cluster drive motors are off-the-shelf, and readily accessible, and they minimize cost while increasing reliability. Use of the cluster drives ensures continuous operability (at slightly lower output), even if one or more needs to be replaced.

Instead of seven-inch shafts, eight-inch Chromoly shafts increase usable life. In place of old HEX shaft design or a double key round shaft, the unit uses a six-key design where the knife literally rides on disposable keys, not directly on the shaft. With the keys taking any abuse instead of the shaft, the design eliminates shaft washout and simplifies knife changes.

Because the unit is designed with a double labyrinth style drop zone and outboard bearings, this eliminates any direct path to the shaft bearings. It also allows compressed material a path to exit the shredder, eliminating the "catastrophic costs" of bearing and shaft replacement.

To further enhance production, innovative shredders like this strike at the root of the processing bottleneck. Instead of using many shredders to progressively reduce the size of composites scrap, new shredder "knife" technology can uniformly cut to any size in a single pass without a screen, very quickly reducing scrap to a reclaimable proportion.

It uses a unique bed knife design in a dual shaft shredder to cut the width of the material of the shredder. The size of the end-product is based on the size and geometry of the rotary and fixed knives as well as their gap distances.

A shredder using this design can produce more than 85 percent correctly sized material in one pass with less than 10 percent oversized material. The knife system can reduce scrap to the appropriate size with much less energy than typical shearing and grinding equipment. Power efficiency approaches 150 percent over any standard shredder.

When the knife technology is used with composites, it can dramatically reduce shipping costs by minimizing voids in containers due to oversized material.

While such units are typically hydraulic, all-electric versions are an attractive option if a very large chamber size is required, but not high torque. All-electric versions are simpler, quieter, less costly, and even easier to maintain since the devices have no valves and cannot leak hydraulic fluid since none is used.

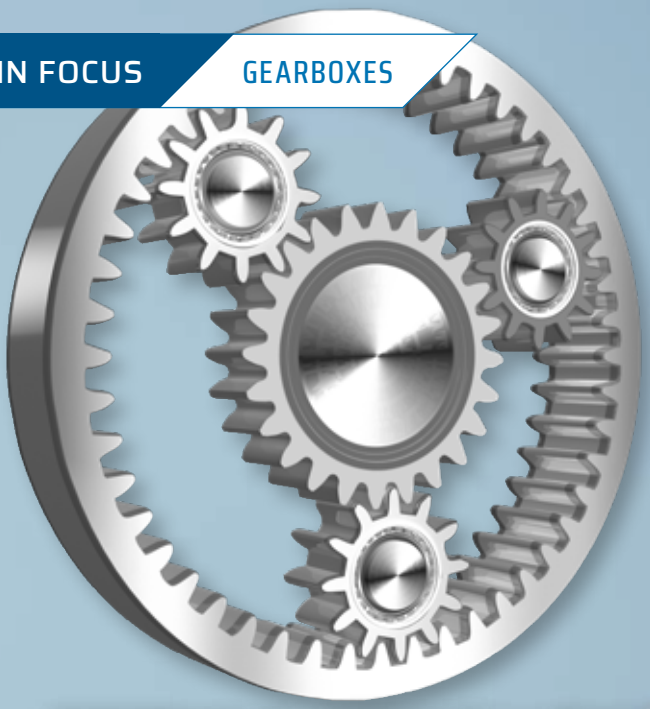
With a programmed "nip cutting" function, customers can save labor during the processing of materials when shredding the entire amount in one stream is not possible. Nip cutting (rotating shafts to cut big hunks into small pieces) saves the operator time trying to disassemble, reduce size, or cut the material to size.

Wind turbine composites recyclers needing high-volume shredding, whether high-torque or not, have been frustrated by costly production breakdowns and bottlenecks.

With industry innovation, however, wind turbine recyclers now have the ability to quickly, efficiently, and reliably reduce even the largest scrap materials and loads to size onsite in a streamlined process. This has the potential to significantly increase production, as well as reduce labor and shipping costs, to boost the bottom line.

ABOUT THE AUTHOR

John Neuens is sales and marketing director of BCA Industries, founded in 1998. Located in Milwaukee, Wisconsin, BCA specializes in developing solutions for recycling equipment, industrial shredders, CNC machining, welding, and customer product designs. For more information: www.bca-industries.com.



FORMULATING LOAD-SHARING BEHAVIOR IN EPICYCLIC GEARS FOR WIND TURBINES

This article validates an analytical model for estimating load sharing of three-planet epicyclic gear sets that has been reformulated for wind-turbine gearboxes to consider the effects of gravity related to carrier-bearing clearance and moments from the rotor.

By YI GUO and JONATHAN KELLER

In an ideal epicyclic gear set, every parallel gear path transmits the same amount of torque. However, it is well known that certain manufacturing variations result in unequal load sharing between the parallel gear paths. Previous works have developed and validated a general closed-form analytical model of this phenomenon that describes the load-sharing characteristics of epicyclic gear sets from three to six planets at any torque level. More recently, this analytical model has been reformulated to include the effects of gravity, carrier bearing clearance, and external applied moments, all of which are relevant to most gearboxes and their mounting configuration in horizontal-axis wind turbines. In this article, the reformulated model is compared to load measurements collected from two similar wind-turbine gearboxes with three-planet epicyclic gear sets. The resulting load-sharing values are also compared to the mesh load factor requirements in the AGMA 6006 and IEC 61400-4 wind-turbine gearbox design standards.

Load-sharing factors as high as 1.16 at extreme rotor moments and 1.08 with no moment were measured for the gearbox with cylindrical roller bearings, but the load-sharing factor remained below 1.10 for the gearbox with tapered roller bearings. Parametric studies of reducing the planetary system mass and carrier bearing clearance, even by modest amounts, resulted in an improvement in the load-sharing factor. The results show that in the wind-turbine application, load sharing is not equal — even for three-planet systems with a floating central member because of the effects of gravity, rotor moments, and the resulting relative motions among the epicyclic gear components within the carrier bearing clearance.

1 INTRODUCTION

Epicyclic gear sets have a number of identical gears, typically called planets, equally or nearly equally spaced on a carrier. They use the symmetry of the planet spacing to split input torque into multiple parallel paths, with each planet ideally carrying an equal portion of the input torque. It is well known that equal loading is not always achieved in practice because of manufacturing and assembly errors, such as carrier pin position error, variation in planet size, and runout of the gears [1]. The degree of inequality in load sharing has major implications for gear system sizing and rating, and the sensitivity to positional errors increases with the number of planets [2]. The effect of these errors on load sharing is accounted for in the design process by the planetary mesh load factor [3, 4], herein called the load-sharing factor.

Floating a central member in epicyclic systems improves planetary load sharing compared to fixed epicyclic systems [5, 6] and, generally, it can achieve equal load sharing for systems with three equally spaced planets [2].

The input stage of many wind-turbine gearboxes uses a three-planet, floating epicyclic configuration, intended to achieve nearly equal load sharing between the planets. However, these gearboxes are often mounted horizontally and in a so-called "three-point" configuration, such that the epicyclic system is subject to not only the rotor torque but also radial loads from gravity and rotor moments [7]. In controlled experiments, load-sharing factors as high as 1.15 for a planet gear and 1.46 for each individual bearing row supporting the planet gear have been measured [8]. Finite-element analyses have shown the unequal load sharing is a combined effect of the rotor moments, gravity, and the contact state of the carrier bearings relative to their clearances, rather than manufacturing errors [8][9].

A general, closed-form analytical model was previously formulated to estimate load sharing considering positional errors for three- to seven-planet epicyclic gear sets and was validated with finite-element analyses [2, 10]. However, this formulation did not consider the additional radial loads on typical wind-turbine gearboxes and their effect on load sharing when combined with clearance in the carrier bearings. This model has recently been reformulated to consider these effects without positional errors [11]. In this article, the reformulated model is validated with the measurements acquired from the previously conducted controlled experiments of two wind-turbine gearboxes with different carrier bearing clearances [8].

2 EXPERIMENTS AND INSTRUMENTATION

Experimental measurements of load sharing acquired from a repurposed NEG Micon 750-kilowatt (kW) wind-turbine drivetrain featuring a three-stage gearbox in a three-point mounting configuration, representative of most utility-scale drivetrain architectures, were used to validate the reformulated model. The two torque arms of the gearbox and the main bearing provide the three points of mounting support. The three-point mounted configuration transfers torque as well as rotor moments through the gearbox to the bedplate. For this work, the original Jahnel-Kestermann PSC 1000-48/60 gearbox, consisting of a single planetary input stage with three equally spaced planet gears followed by two parallel-shaft stages, was redesigned. The redesign features a planetary stage with new bearings and a sun pinion floated with a splined connection to a hollow shaft. Two different planetary

section bearing configurations were designed and built in separate gearboxes. One featured cylindrical roller bearings operating in C3 clearance for the planets and CN-like clearance for the carrier, while the other featured tapered roller bearings under preload, as shown in Figure 1. Other than these planetary system differences and slight differences in gear-tooth microgeometry, the gearbox designs are nearly identical because each uses the same front and rear housing components and intermediate- and high-speed stage gearing [8].

Instrumentation in the planetary gear stage focused on planet-bearing load-sharing characteristics. Thirty-six strain gauge pairs, mostly within the expected bearing load zones, were evenly placed between the upwind and downwind planet-bearing rows in each gearbox, as shown in Figure 2. The roller load at each location was determined by converting the average, measured strain range with calibration factors determined from dedicated bench experiments in a load press and assuming dynamic effects are small [12, 13]. The load-sharing factor was then calculated from the measured planet-bearing loads [8].

The drivetrain experiments were conducted in a dynamometer at the National Wind Technology Center, as shown in Figure 3. Steady-state operations were conducted at a rated speed of 22.1 revolutions per minute (rpm) for the rotor and 1,800 rpm for the generator from offline (i.e., generator disconnected) conditions to the rated electrical power of 750 kW and 325 kilonewton meter (kNm) mechanical torque [14, 15]. Representative rotor moments up to ±300 kNm as measured on the main shaft, based on field experiment results [16], were applied with hydraulic actuators to the adapter shaft connecting the dynamometer gearbox to the main shaft of the drivetrain.

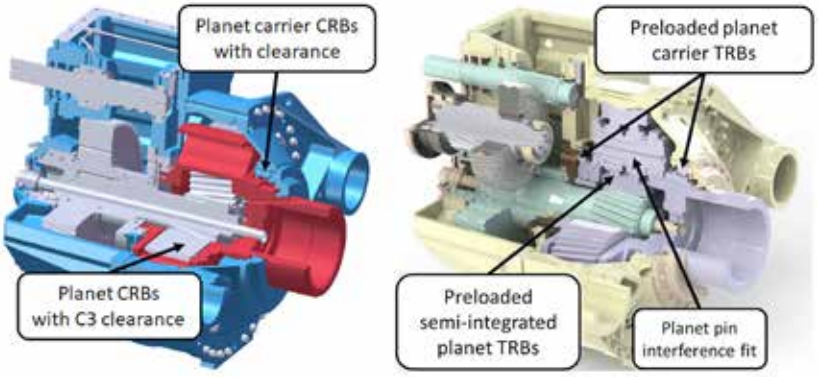


Figure 1: Comparison of the gearbox designs featuring cylindrical (left) and tapered (right) roller bearings. Illustration (right) by Romax Technology.

Figure 2: Planet-bearing instrumentation (left) and partially assembled gearbox (right). Photos by Jonathan Keller, NREL 36522 and 36512.

Figure 3: Dynamometer experiment setup of 750-kW wind-turbine drivetrain. Photo by Mark McDade, NREL 32734.

3 ANALYTICAL MODEL

The free-body diagram of a three-planet epicyclic system, shown in Figure 4, is used to develop the reformulated analytical model. The applied torque, T, results in radial and tangential in-plane loads, $F^{r,t}$, on each planet gear, i. As described earlier, gearboxes mounted in three-point horizontal-axis wind turbines are subject to additional radial loads to the planetary gear set beyond that of the transmitted torque. These additional loads consist of the total gravity load from the planetary system and main shaft, mg, plus external loads, F_{ex}, resulting from the weight moment of the rotor about the main bearing and aerodynamic moments. The carrier and planet bearings can share these loads, de-

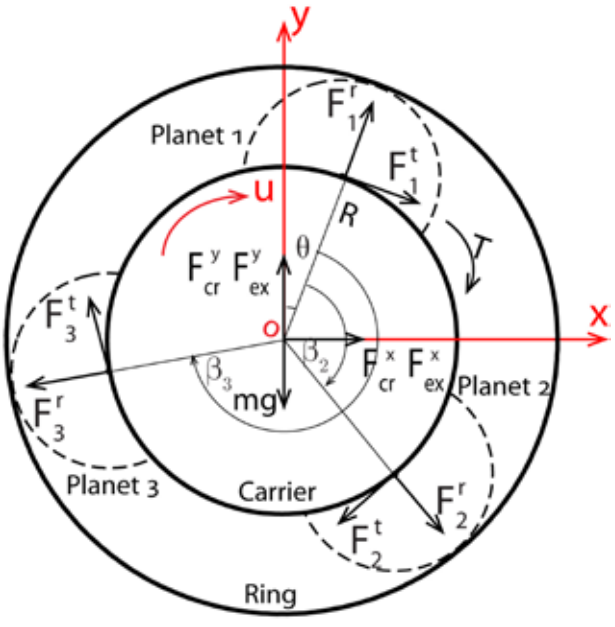


Figure 4: Free-body diagram of the planetary section.

pending on their relative clearances. The reformulated analytic model [11] describes the additional forces in the wind-turbine application and the carrier bearing reaction forces, F_{cr}, the portion of the loads that can be compensated for by system float, and the required torque to bring each planet gear into contact in a process similar to previous work that accounted for positional errors [2].

For a system with three equally spaced planets and sufficient floating, the tangential forces on each planet gear are:

$$F_1^t = \frac{1}{3}\left[T/R + K_m\delta_{rp} - 2\left(F_{ex}^x + F_c^x\right)\cos(\theta+\beta_1) + 2\left(F_{ex}^y + F_c^y - mg\right)\sin(\theta+\beta_1)\right]$$
$$F_2^t = \frac{1}{3}\left[T/R + K_m\delta_{rp} - 2\left(F_{ex}^x + F_c^x\right)\cos(\theta+\beta_2) + 2\left(F_{ex}^y + F_c^y - mg\right)\sin(\theta+\beta_2)\right]$$
$$F_3^t = \frac{1}{3}\left[T/R - 2K_m\delta_{rp} - 2\left(F_{ex}^x + F_c^x\right)\cos(\theta+\beta_3) + 2\left(F_{ex}^y + F_c^y - mg\right)\sin(\theta+\beta_3)\right]$$

Equation 1

where

F_i^t are the tangential forces on each planet, i = 1,2,3.

T is the input torque.

R is the distance between the centers of the sun and planets.

K_m is the equivalent planetary stiffness from the ring-planet gear mesh, K_{rp}, and planet bearing, K_b.

δ_{rp} is the carrier radial motion resulting from gravity and the external rotor moments with respect to the equivalent planetary stiffness, carrier bearing stiffness, K_c, and carrier bearing clearance, Δ_c.

$F_{ex}^{x,y}$ are the lateral, x, and vertical, y, forces resulting from the external rotor moments.

$F_{cr}^{x,y}$ are the carrier bearing reaction forces.

mg is the equivalent weight of the planetary section and the main shaft.

β_i is the relative position of each planet, $\beta_i = 0, \pi/3, 2\pi/3$.

θ is the rotational position of the carrier from the vertical axis.

Although the carrier is typically supported by two bearings on either side of the planets, this formulation assumes there is a single carrier bearing reaction force, F_{cr}, acting at the center of the planets. The carrier bearing reaction force depends on the gear and bearing stiffnesses, carrier bearing clearance, and ring gear backlash [11]. The forces applied to the planetary system from the rotor moments are:

$$F_{ex}^x = M^y/L$$
$$F_{ex}^y = -M^x/L$$

Equation 2

where

$M^{y,x}$ are the rotor yaw and pitch moments, respectively.

L is the distance between the main bearing and the planets.

The constant gravity load and forces resulting from the rotor moments in Equations 1 and 2 cause a once-per-revolution sinusoidal variation in the planet forces [8, 9].

The vector summation of the planet forces can be expressed in terms of a non-dimensional load-sharing factor by dividing by the forces due to torque alone. For a system with three equally spaced planets and sufficient floating and assuming the planet radial forces, F^r, are small compared to the planet tangential loads, F^t, the load-sharing factor is:

$$K_\gamma^* = 1 + \frac{K_m\delta_{rp}}{T/3R} + \frac{2R\sqrt{\left(F_{ex}^x + F_c^x\right)^2 + \left(F_{ex}^y + F_c^y - mg\right)^2}}{T}$$

Equation 3

where

K_γ^* is the maximum value of the mesh load factor over the carrier rotation, $K_\gamma^* = |K_\gamma(\theta)|$ [9].

A load-sharing factor with a value of 1.0 indicates the planets are carrying the expected torque load, while values greater than 1.0 indicate the planets are carrying more load because of the additional forces in the wind-turbine gearbox application or because of positional errors [2]. Key design parameters necessary to calculate the load-sharing factor using the reformulated analytical model are listed in Table 1 for the gearboxes in this study. Although the tapered roller bearings are preloaded [8], the reformulated analytical model simply assumes they have zero clearance.

	Symbol	Cylindrical Roller Bearings	Tapered Roller Bearings
Rated torque, kNm	T	325	
Center distance, mm	R	308	
Distance from main bearing, mm	L	1,800	
Equivalent planetary mass, kg	m	1,850	
Ring-planet gear mesh stiffness, kN/µm	K_{rp}	1.8	
Rotor-side carrier bearing clearance, µm	Δ_c	275	0
Carrier bearing stiffness, kN/µm	K_c	6.0	13.3
Planet bearing stiffness, kN/µm	K_b	2.6	10.2
Equivalent planetary stiffness, kN/µm	K_m	0.50	0.58

Table 1: Gearbox design parameters.

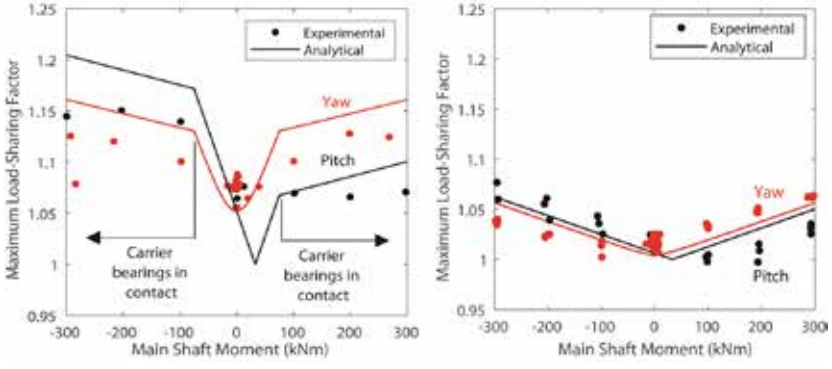


Figure 5: Comparison of measured and predicted maximum load-sharing factors for cylindrical (left) and tapered (right) roller bearings.

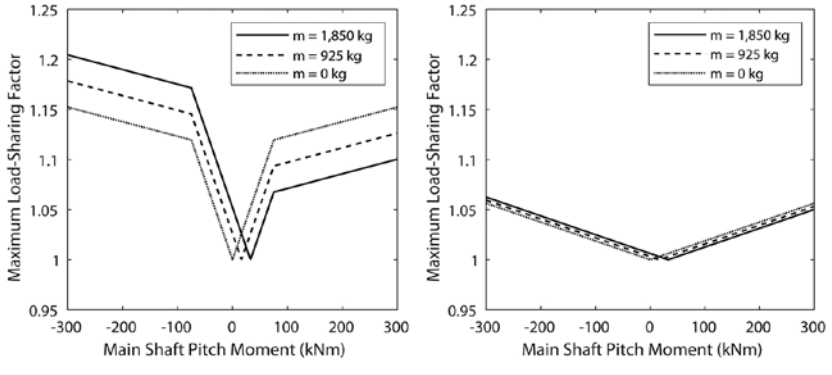
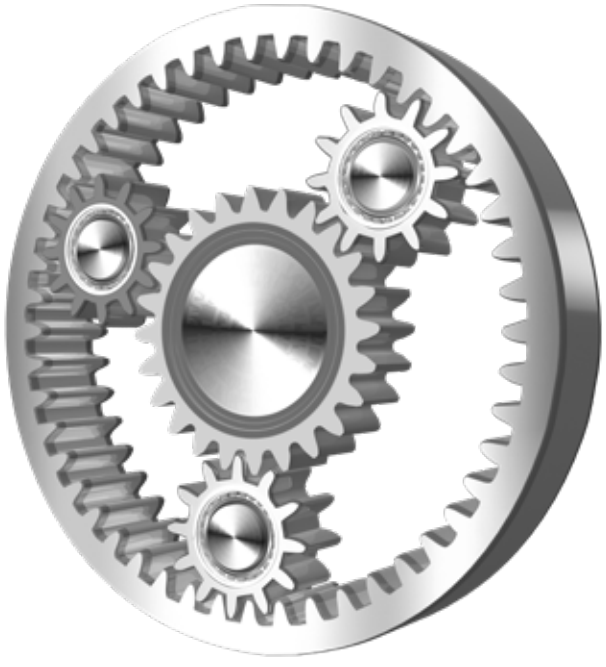


Figure 6: Effect of planetary mass on maximum load-sharing factor for cylindrical (left) and tapered (right) roller bearings.

4 RESULTS AND DISCUSSION

In this section, the reformulated analytical model is applied to the two gearbox designs and compared to the measurements of planet-bearing loads acquired during the dynamometer experiments, as shown in Figure 5. The load-sharing factor has distinct behaviors for each gearbox and whether rotor pitch or yaw moments were applied. In general, though, the load-sharing factor increases with increasing moment, as expected, for both gearboxes. The load-sharing factor is also lower for the gearbox with tapered roller bearings in the planetary system than the gearbox with cylindrical roller bearings.

The most striking load-sharing behavior is for the gearbox with cylindrical roller bearings. With no applied moment, the load-sharing factor is 1.05 because much of the weight of the planetary section and main shaft is supported by the planet bearings. When subjected to small positive pitch moments, the load-sharing factor actually decreases and is predicted to reach the expected value of 1.0 at 33 kNm. This is the pitch moment required to relieve the equivalent weight from the planetary section and main shaft about the distance from the main bearing. As the pitch moment increases beyond this point, the load-sharing factor increases quickly to a value of approximately 1.07 at 75 kNm. In this condition, the carrier bearing has come into contact and is also supporting the pitch moment [8]. As the pitch moment increases even further, the planet loads do not increase as appreciably because the carrier bearings are also supporting the increased loads and the load-sharing factor only reaches 1.1. In contrast, as the pitch moment decreases below 33 kNm, the load-sharing factor quickly reaches higher values because of the additional gravity load on top of the loads resulting



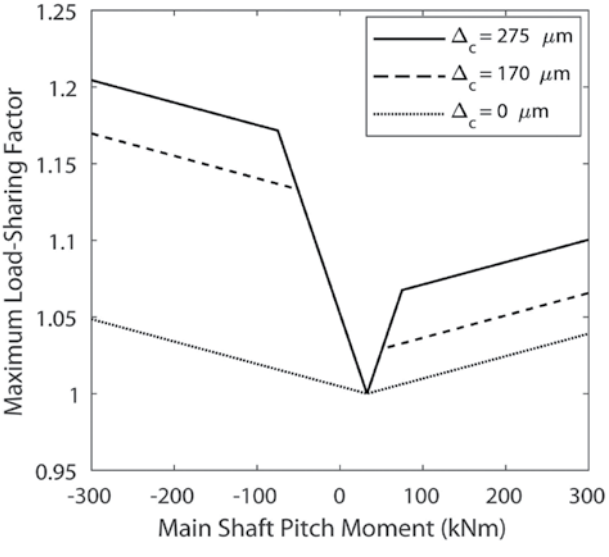


Figure 7: Effect of carrier bearing clearance on maximum load-sharing factor for cylindrical roller bearings.

from the pitch moment. It reaches a value of 1.17 at minus-75 kNm, at which point the carrier bearings again become in contact, slowing from there and reaching a value of just more than 1.20 at minus-300 kNm. Yaw moments have a similar effect on the gearbox with cylindrical roller bearings as the pitch moments, with the load-sharing factor displaying a behavior that is symmetrical with positive or negative yaw moments. Within ±75 kNm, the carrier bearings are not in contact, and the planets support all the loads. Beyond this point, the carrier bearings react to the additional moments, and the load-sharing factor reaches 1.16. The reformulated analytical model predictions generally correspond to the experimental measurements, and, in many cases, the load-sharing factor is above the 1.10 design requirement in IEC 61400-4 [3] and AGMA 6006 [4]. The predictions are sensitive to the assumed carrier bearing clearance of 275 μm, which is difficult to determine accurately because the carrier bearings are a full complement and are affected by fits and bearing temperature. With low-rotor moments when the carrier bearings are either not in contact or only periodically in contact, the measured load-sharing factor is slightly higher than the model prediction.

For the gearbox with tapered roller bearings, load sharing is generally improved, and the predicted and measured load-sharing factors remain below 1.07 even at the highest pitch and yaw moments. Because the carrier bearings are always in contact, the load-sharing factor simply increases linearly for any pitch moment above the 33 kNm required to relieve the gravity load of the carrier and main shaft. With no rotor moment, the load-sharing factor is just above 1.0. For this gearbox, the experimental measurements always remain below the 1.10 design requirement. Both the carrier and planet bearings were designed to have some amount of preload, which tends to increase the planet loads slightly compared to the analytical model, which assumes no clearance or preload.

Figure 6 further examines the effect of the equivalent weight of the planetary section and main shaft by changing the mass of the system in the reformulated analytical model. Only pitch moment cases are displayed. For the gearbox with cylindrical roller bearings, as the equivalent mass is reduced, the behavior of the load-sharing factor becomes more symmetrical about the zero-applied moment and is reduced to a maximum value of 1.15 for the massless system. The point of the lowest load-sharing factor also moves closer to the zero-applied moment, indicating the weight of the system alone is responsible for any increase in the load-sharing factor above 1.0 at the zero-applied moment. The weight of the system has almost no effect on the load-sharing factor for the gearbox with tapered roller bearings, indicating the majority of the weight is always supported by the carrier bearing.

Figure 7 examines the effect of carrier bearing clearance on the load-sharing behavior of the gearbox with cylindrical roller bearings. Reducing the carrier bearing clearance from 275 μm to 170 μm results in a noticeable improvement in the load-sharing factor [8], but naturally only when the carrier bearing is in contact. There is no change in the load-sharing factor when the carrier bearing is operating in clearance. As the carrier bearing clearance is eliminated, the load-sharing factors approach the same values as for the gearbox with tapered roller bearings — the only relatively minor difference in the two systems being a result of the difference in stiffnesses of the planet and carrier bearings.

5 CONCLUSIONS

This article validates an analytical model for estimating load sharing of three-planet epicyclic gear sets that has been

reformulated for wind-turbine gearboxes to consider the effects of gravity related to carrier bearing clearance and moments from the rotor. The predicted load-sharing factor was validated with experimental results for two different gearboxes, one supported by cylindrical roller bearings with clearance and another supported by tapered roller bearings with preload, that were studied in controlled dynamometer experiments. The reformulated analytical model was also used to examine the effect of gravity loads and different cylindrical roller bearing clearance settings in the carrier bearing.

For wind-turbine gearboxes with three planets, equal load sharing cannot be achieved in all cases by floating the central member. Load-sharing factors as high as 1.16 at extreme rotor moments, and even 1.08 with no moment, were measured for the gearbox with cylindrical roller bearings, but the load-sharing factor remained below the 1.10 design requirement in AGMA 6006 and IEC 61400-4 for the gearbox with tapered roller bearings. Reducing the equivalent mass of the planetary system and clearance in the carrier bearings, even by relatively small amounts, improves load sharing for gearboxes with cylindrical roller bearings.

6 ACKNOWLEDGEMENTS

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KEEPING UP WITH MARKET NEEDS

Despite falling costs on the production side, price remains a deciding factor for wind-energy purchasers, and it is just as important as ensuring reliable supply. (Courtesy: NeuerEnergy)

How wind-energy providers can scale their operations to keep pace with growing demand.

By MUHAMMAD MALIK

Stronger focus on net zero goals is driving a huge surge for wind power. According to recent reports, 2020 marked the wind-energy sector's best year so far with 93 GW of capacity installed globally due to soaring demand. While land wind energy growth in the U.S. hit record levels and saw investment of $24.6 billion, European outlay on new wind farms has reached 49 billion euros.

Although wind power is not the only element needed to fuel the transition to net-zero, it's experiencing increased demand as awareness of its importance grows. In fact, studies predict that meeting 2050 carbon reduction targets will depend on global installation progressing three times faster over the next decade.

For wind-energy providers, this presents rapidly expanding opportunities. However, with accelerated adoption also comes greater pressure. Keeping pace with market needs will mean scaling up operations, reconfiguring business models, streamlining systems, and implementing more advanced technologies — or put simply: major IT redesign and modernization.

The question is: How can wind-energy firms ensure their evolution fuels both immediate and lasting benefits — and, most crucially, what does such a major overhaul look like in practice?

MAKING QUICK GAINS AMID INCREASED DEMAND

Despite falling costs on the production side, price remains a deciding factor for wind-energy purchasers, and it is just as important as ensuring reliable supply. This means energy providers must harness precise yet adjustable planning to consistently provide buyers with enticing wind-power offerings, and one of the most efficient ways to achieve that is by leveraging artificial intelligent (AI) solutions.

Modern AI platforms, especially those with API data integrations and cloud-based SaaS applications, can do more than just amalgamate large data sets. Sophisticated algorithms have the ability to evaluate historic information against real-time data and continuously predict cost or spikes in demand. By cross-referencing these insights with climatic sensor data, they can also forecast future energy requirements in line with seasonal fluctuations. This is particularly important when you consider that wind companies typically run distributed operations across multiple time zones and climates.

By ensuring demand is persistently synced to grid load for maximum cost-effectiveness, this allows organizations to both prevent issues and seize opportunities. For instance, identifying upcoming demand peaks means avoiding unexpected outages and allows firms to plan for when extra battery storage is needed to meet market demand — therefore increasing revenue.

Ultimately, the energy providers that can tap into data from varied internal and external sources to align their operations with fluctuating market demand will quickly reap the benefits in terms of increasing short-term revenue opportunities and maximizing ROI.

Another advantage of embracing AI is the scope it brings for wind organizations to broaden their customer base. Specifically, wind-energy providers should consider a platform that aggregates a lot of buyers from different markets through cloud-based subscription applications. Not only does this enable buyers to purchase available energy capacity, but it also ensures wind generators get a guaranteed sale that's good for their bottom line. Unlike traditional wholesale pricing strategies, this process will also ensure SMEs get access to wind energy on terms that work for them. Ultimately, this form of hyper-local demand and supply matching will not only ensure transparency of price for the buyer but also guarantee increased profit margins for energy companies.

BUILDING THE FOUNDATIONS FOR LONG-TERM SUCCESS

It's no secret that digitization is important to future-proof many industries, and the wind-energy sector is no exception. In the longer-term, exploring developments such as digital twin technologies will be critical to ensure power plants can bridge the gap between physical assets and digital systems.

Looking ahead, digital twin technologies are set to play a core role in fueling the shift away from legacy energy infrastructure. By forging links between previously disparate wind-farm facilities, digital twin technologies can enable virtualized management capabilities via a "hive" model. By coupling digital twin technologies with AI and machine learning, energy providers can implement predictive capabilities to identify turbine maintenance needs ahead of time. For example, these technologies will provide predictions on the specific turbines that should be shut off for optimal output, particularly where fluctuating wind patterns make it more conducive to overall production to not have peripheral turbines running.

ENSURING SAFE, FLEXIBLE, COST-EFFECTIVE DATA EXCHANGES

Of course, there are some foundational steps to consider first. Most importantly, virtual maintenance capabilities require a certain level of interoperability to enable safe, flexible and cost-effective data exchanges. Fortunately, wind companies can consolidate data into one cloud-based AI system, helping them to unify datasets across their decentralized portfolio and network of generators and storage locations — harmonizing the data in each location to make

Wind-energy providers should consider a platform that aggregates a lot of buyers from different markets through cloud-based subscription applications. (Courtesy: NeuerEnergy)

them work together in harmony.

From there, businesses will then be ready to harness digital twin technologies to connect the offline world and IT services, such as controls and diagnostics. In addition to enabling the virtual maintenance of complex equipment, constant monitoring will produce data AI and machine learning algorithms can use to anticipate potential unplanned downtime by testing how procedures may perform in different simulated scenarios. Armed with precise predictions of possible holdups, businesses can take proactive action to minimize supply risks with the bonus of gaining more time they can invest in development, collaboration, and enhancing the lifetime of power generation tools.

As the mission to curb negative environmental impact gains momentum, renewables are on an accelerated adoption trajectory that makes swift changes vital for wind companies to deliver the premium products and services now in mass demand. On a near-term basis, harnessing AI technologies to reliably supply power at the right level and price for each market will be essential to secure an early competitive position. When it comes to future-proofing operations, making the most of digital twinning technologies will help wind-energy providers to build agile IT infrastructure. Only then will companies have the capacity to optimize the efficiency and profitability of wind-power generation, persistently.

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Muhammad Malik is CEO and founder of NeuerEnergy.

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Survitec's Evacuator descent device. (Courtesy: Survitec)

Survitec supplies safety equipment for the offshore wind-energy market in order to cover all the survival technology requirements for the complete life cycle of a wind farm.

By WIND SYSTEMS STAFF

The drive toward net zero is seeing a gradual shift away from traditional fossil fuel-based energy sources to cleaner, greener fuels, with many of the world's players reimagining energy for the betterment of people and planet.

The evolution of wind power and other renewable energies is also having a knock-on effect on those suppliers to the traditional energy sectors, with many established companies investing and expanding their roles to support this change. One such company is leading safety and survival solutions provider, Survitec.

A GLOBAL OPERATION

For more than 100 years, Survitec has supplied innovative products and services to the global maritime, aviation, and offshore energy industries, protecting more than a million lives every day, but the company recently reimagined its energy portfolio to include offshore wind, culminating in the acquisition of Norwegian PPE specialist Hansen Protection, which includes the HeliPPE, Lyngsøe, and Biardo brands.

"There are many synergies between the oil and gas and renewable energy sectors," said Jim Cook, Survitec's head of business development for energy. "Both require personnel transfer by vessel or helicopter to offshore facilities operating in harsh weather environments. With offshore wind farms becoming more important to the energy mix and turbine height increasing, we know the safety of our customers' personnel is their No. 1 priority. It's ours, too."

Survitec's portfolio of safety and survival solutions is as extensive as the markets in which the company operates. The range of equipment includes lifeboats and life rafts, lifejackets, immersion suits, fire protection and detection equipment, emergency communications, first aid and medical kits, PPE and height safety equipment.

"We look at the entire safety package requirement for any given sector," Cook said. "For the offshore wind-energy market, this would cover all the survival technology requirements for the complete life cycle of a wind farm—including turbine installation, operation, and maintenance. With the addition of Hansen Protection and its leading offshore PPE rental brand, HeliPPE, we can now deliver the market a complete and comprehensive package."

"Hansen Protection, along with HEliPPE was a good fit for us," he said. "The acquisition has strengthened our position in the sector, resulting in Survitec becoming the global leader for PPE rental in the offshore wind crew/personnel transfer market. Our global reach, together with our multiple brands, products, and services, offers greater value to our offshore wind customers by providing one single partner for all their safety and survival needs. Hansen Protection has built an outstanding portfolio, with a strong reputation for the consistent delivery of excellence. By joining forces, we can deliver our customers more."

STRATEGICALLY LOCATED FACILITIES

Survitec employs more than 3,000 people in 96 countries. This includes eight manufacturing facilities, three DNV accredited training centers, and a support network of more than 400 accredited service stations.

"Our facilities are strategically located for the convenience of our customers," Cook said. "We are known for being where our customers need us and for our responsiveness. For example, our marine business serves 2,000 ports across the world, making us the unparalleled leader with a global reach."

Survitec's position in offshore wind puts the company in a unique position.

The Halo Passenger ETSO. (Courtesy: Survitec)

Immersion suit lifejackets for offshore transfer. (Courtesy: Survitec)

"The key is being a survival-technology-solutions partner for the various customers in offshore wind," Cook said. "Each aspect of an offshore wind project requires a different safety solution. But whether we are dealing with those involved in the development and construction phase or the operation and maintenance side, they will experience the same level of service."

According to Cook, this allows Survitec to better react immediately and efficiently to any challenges the industry may face.

"Remember, although the offshore wind farm dates back to the early 1990s, we have a proven history in offshore safety dating back a lot further," he said. "Our trusted PPE solutions are unrivaled with almost 2 million passenger transfers each year in the North Sea alone. We have decades of experience working with offshore energy customers to develop bespoke safety solutions for their projects.

This strengthens our ability to ensure the safety of personnel working in the offshore wind sector from start to finish.

Although the offshore wind farm dates back to the early 1990s, we have a proven history in offshore safety dating back a lot further.

"As a company, we exist to protect lives," he said. "Our key purpose remains protecting personnel and our customers' assets while ensuring that our vision and mission is totally within that philosophy. Our values are captured around the safety of customers, people, excellence, innovation, and integrity."

NOTABLE INDUSTRY FIRSTS

With innovation and product development the common denominator throughout Survitec's long history, it is not surprising the company is behind a number of notable

> We look at the entire safety package requirement for any given sector. For the offshore wind-energy market, this would cover all the survival technology requirements for the complete life cycle of a wind farm.

firsts. Survitec pioneered the first inflatable life raft in 1920 and then launched the first jet escape suits and the first submarine escape suits. It was the first to introduce a SOLAS-approved life raft, followed by the first gas-operated lifejackets and full-coverage anti-G suits. The world's first aviation lifejacket with emergency breathing system (EBS) was designed and brought to market by Survitec in 2014.

In 2019, Survitec unveiled Halo, a new aviation lifejacket with compressed air EBS for offshore helicopter passengers designed to offer personnel 80 percent more breathable air than the industry standard.

"With more than 60 years' market-leading experience in lifejacket design, coupled with extensive industry insights, we have been able to design a lifejacket that sets a new standard in helicopter transfer safety," Cook said. "Halo is a huge step forward in lifejacket comfortability and in-water safety performance."

AWARD-WINNING DESCENT SYSTEM

And Survitec continues to improve upon its safety game by offering an award-winning descent system for offshore wind. The Evacuator moves away from a rope-based descent system to a more user friendly, mechanical evacuation process designed specifically for wind turbine technicians, according to Cook.

"This system provides a quick and intuitive escape and descent solution for your technicians in an emergency situation," he said. "It is suitable for installation on wind turbines, offshore substations, harbor cranes, and other high-rise structures."

Survitec's innovative products will no doubt be a major asset to offshore wind operators expecting to grow exponentially over the next 10 years.

"We're obviously going to see globally, the offshore wind market will grow from 29 GW, as it is today, transitioning to a global install base of 234 GW by 2030," Cook said. "We're seeing in the U.S., Scotland, and South Korea, that offshore wind is going to be the key renewable energy source over the next 10 years. We are putting offshore wind very much at the forefront of our business development strategy, and our recent acquisition of Hansen Protections is indicative of that commitment."

MORE INFO www.survitecgroup.com

Survitec's portfolio of safety and survival solutions is as extensive as the markets in which the company operates. (Courtesy: Survitec)

Joseph Triepke

Partner ◤ Lium

"With the change in the White House this year, you've just seen (the offshore wind) sector get turbocharged."

◤ What is your role with Lium?

I'm a partner in the research practice at Lium, where we cover power, renewables, and shale.

We're a hybrid data service/equity research platform. Our focus is on providing predictive data and reports for investors and executives who are deploying capital into the energy sector and renewables.

We cover both offshore and onshore wind power, with a geographical focus on the U.S.

◤ With U.S. offshore wind taking off, what is being done to address the U.S.'s immature supply chain, and why is the supply chain considered immature?

Starting with the second question first on why it's immature, we've written that we see 2021 as an inflection year in the sector — it's a transition year from plans on paper to steel in the water.

A new sector is emerging from a long incubation period into actually building everything that has been planned. Because the focus has been on development planning, technology, financing, and the regulatory and permitting hurdles; there is no supply chain. We've never built this stuff at scale in the U.S.; we've only planned it and thought about it and talked about it for a decade.

In terms of what's being done, to circle back to that question, you're seeing the first inning of capital deployment in the story now. The sector stands at the cusp of investing hundreds of billions of dollars in Capex. And this is going toward building infrastructure, repurposing facilities, manufacturing the actual equipment like turbines and vessels that are needed, and also assembling the workforce.

◤ How do you see regional markets developing around the U.S. offshore complex?

If you asked us that question in five to 10 years, we'd probably be talking about two markets. There's going to be the East Coast and the West Coast, and both will be climbing up the development curve. Each of these, East Coast and West Coast, have very different problems to solve.

The West Coast is going to be a floating offshore wind market, and so that'll come with different assembly and quayside requirements, different kinds of equipment. And the East Coast will be fixed bottom, so that comes with its own issues. If you think maybe shorter term between now and 2025, most of the development will be on the East Coast. It's just further along the curve technologically and regulatory speaking.

In that near-term timeframe, you'll probably see these markets develop within state lines. There are various reasons for that. Certain states are promoting the space more. And some of them are approaching it more locally in terms of development and diversity and build-out. And we're seeing an interesting phenomenon where localized roof line for the companies is going to factor heavily into contract awards.

You're already starting to see some of this happen with turbine packages, where we can already start to see some of the manufacturers dominating within state boundaries. And that'll be interesting. Guys who invest more in a particular state will have a better shot of winning contracts there.

In the short run, as we think about North Carolina and New York, Massachusetts, Maryland, these all might look a little different and proceed at different paces. But then, as you start to achieve scale a few years down the road, it's going to just be thought of as the East Coast market.

◤ Will this dovetail into a domestic manufacturing boom? And what factors are involved in making that happen?

The short answer is yes. We see a huge boom coming and I think, to elaborate, we'd raise three key points related to your question: First, I think the market is generally underestimating the size of this opportunity. We've seen third-party estimates that fall into the $100 billion to $150 billion spend range. At Lium, we are modeling north of $200 billion in U.S. offshore wind Capex spending over the next 10 to 15 years. Consensus expectations are too light for a couple of reasons

including development acceleration under (President) Biden, indirect infrastructure requirements, and inflation.

The second key point is that developers are going to focus on local content. That's going to be a key element of the story. It's part of the reason why these developers have been able to sell these projects to local communities. There's going to be a large build-out of factories, foundries, assemblies, mills, ports, etc. We're already seeing some of those investments begin. And a lot of Capex will be invested that way driving domestic manufacturing.

And finally, the third point is what we're seeing is just the regulatory climate. With the change in the White House this year, you've just seen this sector get turbocharged. So, there's a big push on the regulatory front that will drive domestic content.

How does the Jones Act put a market wrinkle in offshore construction, and what can be done to tackle that challenge?

The Jones Act requires that commercial activity in U.S. waters utilizes vessels built, owned, and operated by U.S. citizens. Since this pertains to transport, we will likely see some foreign-flagged installation vessels used. In fact, with the very first handful of U.S. turbines installed, we have seen that happen where equipment is ferried using U.S.-flagged vessels to foreign-flagged wind-turbine installation vessels.

But as we think about the next couple of years, there's going to be a need for a lot of vessel construction, both from the Jones Act perspective, and those will be your crew transport and supply transport vessels, but also on the installation vessel front. And we're seeing the start of that now. I think the first two WTIVs that are U.S.-destined have been ordered, and we're going to see a lot more. And the reason is that, even if you look globally — and we track about 30 vessels outside of China that could do work in the U.S. — if you look at those vessels, No. 1, they're very busy in their markets, which would be Asia Pacific and in the North Sea. And, No. 2, a lot of those vessels are too small to handle the new size of turbines that we're seeing on the U.S. projects. You're going to have to build larger vessels and, in general, more vessels to accomplish the power gen targets that we see for U.S. offshore wind.

Bottom line, what does offshore wind mean for the job market?

Bottom line is, probably close to 50,000 jobs directly in the sector, with another 25,000 to 40,000 jobs created indirectly to support the industry. It's going to be a jobs juggernaut, a massive employer over the next 10 years. Positions will include some high paying, good, stable jobs in manufacturing, construction, engineering, marine, and more.

One interesting thing that we looked at over at Lium was to analyze job openings across the renewables landscape, and we have already seen, this year in fact, that U.S. offshore wind hiring trends have surpassed some other notable segments in renewables. Open positions this summer in U.S. offshore wind were roughly the equivalent of utility scale solar, which is huge.

That kind of puts in context some of the urgency around workforce assembly and really this beginning of the supply chain journey.

Offshore wind is expected to be a jobs juggernaut.

Turbine manufacturers will no doubt see a huge increase in business, but what does offshore mean for some of the tangential businesses that could profit in this venture?

I think that's huge. And everyone's going to look at the turbine guys first, because they're the most visible, and they announce big awards, and they're leading edge, but we're tracking a couple dozen publicly traded companies outside of the turbine manufacturers that have large exposure to U.S. offshore wind. And a lot of them are developing divisions or hiring business development specialists to go after the space and talking a lot about this opportunity to investors.

One of the things to watch will be companies that have been involved in U.S. offshore oil and gas activity repurposing their assets and in-house talent pools to serve this new industry — such as the helicopter companies, the boat companies, a lot of the engineering and service companies. And again, that's 24 or so public companies, but there are over 700 private companies that we've identified that are chasing opportunities in the space as well. And these are not turbine manufacturers. This will be a huge opportunity for companies outside of turbine specialists.

MORE INFO lium.com

Ampelmann's A-type motion-compensated gangway will be the first of its kind in China. (Courtesy: Ampelmann)

CONSTRUCTION

Ampelmann to provide gangway to Chinese renewables market

Ampelmann has signed its first contract in offshore China and will provide the A-type gangway, one of its flagship systems, to Guangdong Safety New Energy for the offshore wind works off Guangdong province.

The company will provide by the end of October the A-type on the client's new 60m Service Operation Vessel (SOV) named MV Guang An Yun Wei 88. It will be first SOV equipped with a motion-compensated gangway in China. The system will enable the safe and efficient transfer of personnel at Guangdong Yangjiang offshore wind farm, the largest wind farm in Guangdong.

The farm is 40 nautical miles offshore where turbines will be installed at a depth of about 40 meters.

"We are very excited about this opportunity," said Vincent Chua, business developer at Ampelmann. "With it, we can show the value of our systems and raise the standard of both safety and efficiency of offshore access operations in the area."

China, like many governments, has set ambitious targets for green energy generation, In the Guangdong area, where the project with Ampelmann is located, China plans to install 10 GW by 2030, part of the plan to achieve 40 GW nationwide by that same year.

Guangdong Safety New Energy's venture with Ampelmann will be for a minimum period of six months and could be extended for another six. The project will be the first time a proven full motion-compensated gangway is used in a Chinese offshore access operation.

Ampelmann's greatest value is provided by its operators.

"They are the ones who ensure the efficiency and safety of our operations," Chua said.

The company is looking at training local operators to support future projects in the area.

MORE INFO www.ampelmann.nl

Pemamek's wind tower welding platform. (Courtesy: Pemamek)

CONSTRUCTION

Pemamek offers custom welding for offshore platforms

Pemamek LLC specializes in modular customized automated welding systems for large offshore wind-energy platforms. Difficult-to-weld components comprising monopile and floating platform bases can be joined by combining a customized selection of fit-up and adaptive robotic welding technologies, rollerbeds, column and booms, and other systems, all controlled by one operator and one software system.

The thick heavy plates found in most monopile and floating platforms must be welded together perfectly to avoid loss of strength to hold towers that weigh thousands of tons. Pemamek's 100- to 1,200-ton rollerbeds are designed to reduce seam volume and decrease the amount of needed filler material, featuring a hydraulic anti-creep function to prevent axial movement during welding. Multiple rollerbeds can be included in the overall welding system, communicating weight shifts via positioners for optimal alignment when joining the top and bottom sections of the monopile. One person controls the entire system using the WeldControl 100 and 500 weld management systems, creating a safer work environment, eliminating the need for cranes and multiple welders.

"Welders can preset all welding parameters based on data collected via scanning," said Michael Bell, sales director for Pemamek North America. "Several welds can be performed at the same time by one operator, working from digital measurements taken from the actual workpiece. The guesswork is eliminated and there will be virtually no mistakes with the weld with our adaptive fill technology. This is crucial when joining large plates that will be placed in harsh marine conditions."

The PEMA Flange Fitting Station

can be added to the workshop configuration, enabling fast, safe, and accurate fitting and welding of flanges to wind tower and monopile foundation sections.

The FF station is flexible enough to handle variations of flange designs and can be integrated with PEMA Column & Boom, which enables welding to be done in the same place, reducing weld time and increasing welding efficiency.

Pemamek provides welding automation technology and integrated manufacturing solutions to a wide range of industries including shipbuilding, alternative energies, heavy fabrication, oil and gas, wind energy and boiler manufacturing.

The company offers welding positioners, column and boom units, roller beds and robotic solutions as well as its PEMA WeldControl operating and control software.

MORE INFO pemamek.com

The Liebherr LR 11000 lattice boom crawler will arrive in spring 2022 and boasts a 1,200-ton capacity and 551 feet of main boom. (Courtesy: ALL Family of Companies.)

CONSTRUCTION

ALL Family's new crane to be largest in fleet

The ALL Family of Companies is a few months away from receiving the largest crane in its fleet.

The Liebherr LR 11000 lattice boom crawler will arrive in spring 2022 and boasts a 1,200-ton capacity and 551 feet of main boom. It's suitable for all types of work including infrastructure, wind power, and industrial construction, and maintains strength in constricted working conditions.

The company expects the crane will be in high demand. With transport weights that can be reduced to 45 tons and a transport width of 11 and a half feet, it will easily deploy across ALL's North American footprint.

"As wind towers have gotten taller and plants have become more sprawling, the need for a big crane with high capacities and extended reach has become clear," said Rick Mikut, ALL's crawler crane division manager. "The Liebherr LR 11000 offers exactly what these and other customers have been looking for. Even at 50 percent to 70 percent of load, the LR 11000 offers plenty of capacity to make the big lifts."

The crane includes features such as infinite adjustment of the suspended ballast using V-frame, the hydraulically adjustable folding frame, and VarioTray detachable ballast system that saves the need for stacking and unstacking on a job.

Another available option for ALL customers is Liebherr's P-boom system, which further increases lift capacity. A second lattice boom is mounted parallel to the other at the bottom and merged together at the top to form one single boom.

The ALL Family of Companies is the largest privately held crane rental and sales operation in North America.

MORE INFO www.allcrane.com

Schematic representation of the production of green hydrogen within the flagship project H2Mare. (Courtesy: Fraunhofer Institute for Wind Energy)

INNOVATION

H2Mare project to produce green H2 on industrial scale

The H2Mare project aims to establish a new type of offshore wind turbine, one that integrates an electrolyzer for

direct conversion of electricity to produce green hydrogen on an industrial scale.

This way, the self-sufficient units can save costs of connection to the grid and contribute to the reduction of greenhouse gas emissions. In a second phase, the green hydrogen can be converted into synthetic fuels and energy carriers.

The German Federal Ministry of Education and Research is funding the project."We are bringing in our offshore wind and electrification capabilities as well as our expertise in electrolysis," said Christian Bruch, Chief Executive Officer of Siemens Energy AG.

"H2Mare unites the strengths of research and industry — for sustainable decarbonization of the economy and to the benefit of the environment."

The project comprises four joint projects that are promoted independently of each other, with a total of 35 partners. Those projects include:

- **OffgridWind:** A turbine concept that realizes electrolysis directly in the offshore wind turbine.
- **H2Wind:** Aims to improve the maximum yield of wind energy, consisting of the development of a proton exchange membrane electrolysis system.
- **PtX-Wind:** Focuses on converting to more easily transportable, synthetic energy carriers and fuels, such as methane, methanol, and ammonia. Direct saltwater electrolysis is also being tested.
- **TransferWind:** Addresses transfer of knowledge to the public and exchange of expertise across multiple projects.

This will involve consideration of the entire value creation chain: from wind-energy generation and hydrogen production to the conversion of hydrogen into methane, liquid hydrocarbons, methanol, or ammonia right up to use in industry or the energy sector. The goal is a significant cost advantage in the production of large volumes of hydrogen.

MORE INFO www.iwes.fraunhofer.de

The Paralleling System is ideal for ensuring that critical loads experience no interruption when transferring between all power source assets in renewable energy installations. (Courtesy: Russelectric)

INNOVATION

Russelectric offers system for renewable energy installation

Russelectric, a manufacturer of automatic transfer switches and power control systems, has introduced the Paralleling System for ensuring no interruption of critical loads when transferring between power source assets.

The system can be configured for peak shaving and utility-sponsored load curtailment programs and offers high resiliency, power continuity and security for critical renewable energy installations.

Paralleling Systems incorporate dual, redundant, hot synchronized programmable logic controllers (PLCs) for system control. Discrete switches, meters, and control devices are standard to allow manual control capability in the event that both system PLCs fail. The system provides soft loading transfer and phase lock synchronizing when paralleling with the utility, which reduces transients and controls the loading to the engine generators.

Russelectric provides basic or custom SCADA for local or remote monitoring of all power system functions. Custom SCADA systems allow users to monitor system operation, acknowledge alarms and review PLC setpoints.

The Paralleling System offers a choice of either momentary paralleling with the utility or sustained paralleling for soft loading. Also available is paralleling of generator sets with the utility upon return of the utility source after power interruption. Selector switches are provided for open/closed transition, automatic/manual paralleling of generators and utility sources, and automatic/manual retransfer between both sources of power.

System operation begins with testing in closed-transition mode with no interruption of the load. Generators are then paralleled with the utility and the load is transferred to them. Upon completion of testing, the load is retransferred through closed-transition to the utility source without disturbance.

Utility Paralleling Systems can also be used in financial institutions, data centers, telecommunications, airports, healthcare facilities, and water and wastewater treatment plants.

MORE INFO www.russelectric.com

INNOVATION

ONYX Insight launches pitch bearing monitor

ONYX Insight has launched ecoPITCH, a hardware solution that predicts where and when pitch bearing failures occur in wind turbines.

Pitch bearing faults are difficult to predict and expensive to fix when left undetected, especially in offshore turbines. This failure mode is a significant problem for wind farm owners. Pitch bearings connect the rotor hub to the blades, and the costs associated with fixing the faults are high, particularly if the turbine is offshore. A pitch bearing failure can even lead to the catastrophic loss of a blade.

"This is a really exciting and forward-thinking addition to ONYX Insight's suite of tools and services, which are all geared towards improving turbine efficiency and reducing maintenance costs," said John Coultate, ONYX Insight's head of product development.

"Pitch bearings are particularly difficult to monitor in real time, and our customers want absolute confirmation as to which bearings to change and when," he said. "We now have a revolutionary offering for assessing and comparing damage on any turbine or wind farm, which has the potential to save operators and owners significant capital in unscheduled maintenance."

Pitch bearing failure is a significant problem in the wind industry. Pitch bearings connect the rotor hub to the blades and experience high loading during the life of a turbine. In the most extreme cases, a pitch bearing failure can lead to the catastrophic loss of a blade — obviously an event that must be avoided.

ONYX Insight provides software, services, advanced sensing, and data analytics for gearboxes, drivetrains, bearings, and rotating machinery within the wind sector.

MORE INFO onyxinsight.com

Pitch bearing faults are difficult to predict and expensive to fix when left undetected, especially in offshore turbines. (Courtesy: ONYX Insight)

The upgrades to SG's 5.X platform deliver more competitive power output. (Courtesy: Siemens Gamesa)

INNOVATION

Siemens Gamesa upgrades onshore wind platform

Siemens Gamesa has upgraded the rating of its 5.X onshore platform, increasing its power output to 6.6 MW. The new 6.6-155 and 6.6-170 turbines will offer increased unitary power, delivering a lower levelized cost of energy (LCOE) for customers.

"Technology like this helps Siemens Gamesa to unlock the full potential of wind by increasing the power output of our turbines and deliver more pioneering solutions in the onshore sector," said Lars Bondo Krogsgaard, Siemens Gamesa's onshore CEO.

The increase will optimize performance in high-, medium-, and low-wind conditions for SG's 5.X platform. Both turbines can now provide greater annual energy production and optimized project. The modular, flexible design eases logistics, construction, operation, and maintenance costs, as well as reducing the OPEX, which results in a lower energy cost for projects.

Both turbines combine a flexible power rating from 5.6 MW to 6.6 MW with two of the largest rotor diameters in the market, 155 and 170 meters. The new rating configures the SG 5.X as the highest-yielding onshore turbine in the industry.

The first prototypes are connected and in the testing phase — the 6.6-155 in Alaiz, Spain, and the 6.6-170 in Hovsore, Denmark.

"Technology like this helps Siemens Gamesa to unlock the full potential of wind by increasing the power output of our turbines and deliver more pioneering solutions," Krogsgaard said.

MORE INFO www.siemensgamesa.com

MAINTENANCE

GWO forecasts need for safety training

Global Wind Organisation figures point to an urgent need for investment in standardized safety and technical training. The industry-owned non-profit predicts more than 25,000 people will need entry-level training to work on offshore wind turbines over the next five years.

"Many training providers have already responded to demand by certifying to GWO standards, but investment must pre-empt development and be ready to deliver as soon as foundations begin to be placed in our waters," said Dan Ortega, GWO North America representative.

The training is essential for jobs in construction, installation, operations, and maintenance segments of the wind-power value chain and does not cover jobs in procurement, manufacturing (the most labor-intensive segment), or transport.

A pipeline of almost 100 community colleges, maritime academies, and

Forecasts for offshore wind installation on the East Coast of the U.S. point to an immediate need for investment in standardized safety and technical training. (Courtesy: Global Wind Organisation)

universities from across North America are seeking certification to provide the wind-industry-recognized GWO standards.

"Together, these institutions will help deliver safety on the job, reduce duplication in training, and improve the productivity of tens of thousands of people working on wind turbines offshore in the U.S.," Ortega said.

"Manufacturers and owner operators have created GWO standards to work safely according to the known risks and hazards they face every day," said Wesley Witt, Siemens Gamesa Renewable Energy head of quality management and HSE in SG's Americas region.

GWO is a non-profit group of wind-turbine owners and wind-turbine manufacturers committed to the creation and adoption of standardized safety training and emergency procedures.

MORE INFO www.globalwindsafety.org

Vestas is using its EnVentus platform for what will be New South Wales, Australia's largest wind farm. (Courtesy: Vestas)

MANUFACTURING

Vestas secures 396-MW order for Australia project

Vestas has secured a 396-MW contract for the Rye Park Wind Farm in New South Wales, Australia. It will be the second project in Asia Pacific to feature Vestas' EnVentus platform.

Vestas will supply and install 66 V162-6.2 MW wind turbines in 6.0 MW operating mode.

Rye Park Wind Farm will be Vestas' second-largest Australian project, and it will be the largest wind farm

Goldwind's PMDD onshore GW 5S smart wind turbine features a 165-meter rotor diameter and hub heights that can range from 100 to 130 meters. (Courtesy: Goldwind)

in New South Wales.

In addition to providing clean energy for the equivalent of approximately 215,000 homes annually, Rye Park Wind Farm will create about 250 jobs during the peak of its construction and up to 10 ongoing regional jobs during its operational life.

The project is a partnership with Tilt Renewables, which is now part of the leading Australian renewable energy generator Powering Australian Renewables (PowAR),

"Vestas values our partnership with Tilt Renewables and PowAR as we build on our existing footprint of nearly 400 MW of wind energy in Australia," said Peter Cowling, head of Vestas Australia and New Zealand.

Delivery of Vestas' wind turbines is expected to occur in the third quarter of 2022, with commissioning to commence in the second quarter of 2023.

MORE INFO www.vestas.com

MANUFACTURING

Goldwind reaches 5-MW milestone

Goldwind Science and Technology has completed the installation and grid connection of its GW 5S Smart Wind Turbine test unit, marking a milestone in Goldwind's evolution of high-performance and large-megawatt (MW) permanent magnet direct-drive (PMDD) onshore wind turbines.

"Goldwind has a methodical and calculated method to its development and release of wind turbines and other clean energy technologies," said Goldwind president Cao Zhigang. "The GW 5S wind turbine is our most powerful onshore turbine to-date that takes into account global wind market requirements, customer direction, and extensive research and development — further marking it as a top-rated turbine among Goldwind's already impressive suite of mature PMDD turbine platforms."

The GW 5S platform has a structured design rooted in Goldwind's PMDD turbine technology and incorporates attributes from its predecessors, the GW 3S and 4S, including expandable capacity, high power generation, high reliability, intelligent control systems, and grid-friendliness.

"Goldwind's 5-MW turbine underscores our technological depth and ability to bring trusted products and services to our customers and their projects," said Wu Kai, vice president of Goldwind and general manager of Goldwind International Holdings.

The GW 5S made its initial debut at the 2020 China Wind Power (CWP) conference. The test unit was installed in China in late July 2021 and was grid connected in mid-August. It will now undergo a series of testings.

MORE INFO www.goldwind.com

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Giving Wind Direction
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IRELAND: GREEN LEGACY, GREEN FUTURE

Wind energy is both Ireland's largest and cheapest renewable electricity resource. (Courtesy: Nicholas Doherty/Unsplash)

With a thriving ecosystem of innovation tailor-made to help companies achieve their goals, not only in sustainability but in international growth and expansion, Ireland is an environment primed to support continued business recovery and continued momentum in sustainability.

By JESSICA BENSON

Ireland has long been associated with the color green. And today, the country hopes businesses make that connection with Ireland's bold steps toward building a thriving green economy.

In fact, Ireland has a strategy to become a major investment hub for companies focused on sustainable and renewable growth. In January 2021, Ireland announced the National Recovery and Resilience Plan as a result of the COVID-19 pandemic. As stated in the plan, advancing the green transition was listed as a top priority for the Irish government as it continues its efforts to meet the country's green economy goals. One of these goals includes cutting greenhouse gases by 51 percent by 2030, highlighting an urgent need to invest in a more sustainable economy to ensure this goal is met.

Additionally, business leaders grappling with the best way to hit sustainability targets, while addressing challenges such as energy price spikes, resource shortages, and environmental issues, are looking for the most strategic opportunities to "green up" their operations. With an abundance of natural resources, an existing pool of highly skilled workers, a thriving R&D environment, and supportive government policies, Ireland offers the expertise needed to explore new technologies and energy efficiencies to address the demands for renewable energy.

LEADING WITH WIND POWER

Harnessing the power of wind energy is a priority in Ireland. As the largest contributing resource of renewable energy in the country, wind power provides more than 85 percent of Ireland's renewable electricity and 36 percent of total electricity demand.

The country has one of the largest marine territories in the EU — roughly 10 times the size of Ireland's landmass. And with 220 million acres of marine territory extending beyond the Irish coastline, offshore wind is a key contributor to Ireland's decarbonization effort.

As stated in its National Energy & Climate Plan, Ireland aims to develop 5 GW of additional offshore wind energy by 2030 and 30 GW of wind energy in the next 20 years. This plan is coming closer to fruition with two new projects in the pipeline: the Codling and Moneypoint wind farms. Together, these projects will bring nearly 3 GW of offshore wind capacity to Ireland.

The Codling wind farm plans to develop 1.5 GW of offshore wind energy in the Irish Sea and could produce its first electricity by 2027. The Moneypoint wind farm will be part of a larger green energy hub, helping Ireland become a leader in green energy production.

MONEYPOINT: A STRATEGIC OPPORTUNITY

Recently, Irish utility ESB and Norwegian energy company Equinor announced they are partnering on a 1.4-GW floating offshore wind farm off the coast of Clare and Kerry counties.

Once complete, the wind farm will be capable of powering more than 1.6 million homes in Ireland. The Moneypoint wind farm is replacing Ireland's only remaining coal-burning power plant, which the Irish government and ESB have committed to ending by 2025 as part of the National Climate Action Plan.

The current Moneypoint power plant, built in the 1980s, is home to one of the deepest ports in Europe. This makes it an ideal staging ground for the construction of the wind farm. The deep-water port allows for easier maintenance as wind turbines are brought back onshore for routine service.

A SUSTAINABLE COMMITMENT

Ireland is proving its commitment to sustainability in other ways as well.

MIT Technology Review's 2021 Green Future Index ranked Ireland fifth out of 76 economies on its progress and commitment toward building a low carbon future. This recognition reflects the comprehensive approach taken by the Irish government to act as a leader in sustainability.

Ireland's ambitious Climate Action Plan 2019 outlines 200 actions vital to shifting to a climate-neutral economy. One of the most significant actions for businesses with operations in Ireland is the move to generating 70 percent of all electricity from renewable sources — including on-and off-shore wind farms — by 2030.

Additionally, in March of this year, the Irish government approved the Climate Action and Low Carbon Development (Amendment) Bill 2021. The bill puts the country on the path to net-zero greenhouse gas emissions by 2050 and achieving a 51-percent reduction in emissions by the end of this decade.

Once ratified, the bill will enshrine the targets in legislation, establishing a legally binding framework with ambitious targets and commitments set in law. The bill ensures the necessary structures and processes are embedded on a statutory basis to ensure Ireland achieves its national, EU and international climate goals and obligations.

PRIMED FOR PROGRESS

To support the broader initiatives of the Irish government as

As the largest contributing resource of renewable energy in the country, wind power provides more than 85 percent of Ireland's renewable electricity and 36 percent of total electricity demand. (Courtesy: Waldemar Brandt/Unsplash)

well as private sector initiatives, IDA Ireland, Ireland's industrial development agency responsible for the attraction and retention of inward foreign direct investment into Ireland, is supporting decarbonization and responsible production across its client base. Many multinational corporations — including 31 of IDA's top 40 clients — have signed on to the global Carbon Disclosure Project, including Microsoft, Alphabet, Johnson & Johnson, DELL, and Apple. The agency is also seeking out new investments that will focus not only on decarbonization, but also align with sustainable use and protection of water and marine resources, pollution prevention, and the protection and restoration of biodiversity and ecosystems.

In 2020, the Irish economy proved incredibly resilient during the pandemic, with an estimated GDP growth of 3.4 percent boosted by strong export growth in life sciences and continued strength in the technology sector. Ireland is known for its consistently pro-business policies, and unprecedented government support for business helped stabilize the economy and put it on the road to recovery.

Multinational corporations with operations in Ireland have benefited from this support and demonstrated remarkable resilience. In fact, the companies supported by IDA Ireland saw employment growth of 3.6 percent for 2020.

With a thriving ecosystem of innovation tailor-made to help companies achieve their goals, not only in sustainability but in international growth and expansion, Ireland is an environment primed to support continued business recovery and continued momentum in sustainability.

A WINDY FUTURE: LOOKING AHEAD

Wind energy is both Ireland's largest and cheapest renewable electricity resource. The long-term potential for Irish offshore wind energy is at least 30 GW of wind power, with other estimates even higher at more than 70 GW of wind power.

Floating offshore projects have the potential to transform Ireland into an energy exporter, creating multiple investment opportunities in the upstream and downstream supply chain and R&D, including green hydrogen production.

With the creation of the Moneypoint and Codling wind farms, Ireland is perfectly positioned to be a hotbed of innovation in wind energy in the coming years and a major investment hub for companies focused on sustainable and renewable growth.

ABOUT THE AUTHOR

Jessica Benson is a vice president with IDA Ireland. Benson is based in Boston and supports green and engineering companies in New England and Canada to establish and grow operations in Ireland. Benson previously held economic development and international tax advisory roles with Enterprise Ireland, the Central Bank of Ireland, and Deloitte in the U.S. and Ireland. IDA Ireland is the Irish government agency responsible for the attraction and retention of inward foreign direct investment into Ireland. For more information, go to www.idaireland.com. Follow Jessica on Twitter: @Je_Benson and LinkedIn: linkedin.com/in/jessicabensonirl.

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