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The Growth of Drones in the Wind Energy Industry

By Tom Brady

Smaller computers and sensors, better battery technology, and vastly improved algorithms for managing flight and safety have transformed drones from a niche hobby into a global craze over the last three to five years. Drones that once required a professional pilot to operate effectively are now essential tools for businesses spanning every industry from delivery to industrial inspection. However, drone technology is still at the tip of the iceberg in terms of what's possible. As such, many businesses have opted to wait to see what technologies and vendors emerge as leading providers of drone services and technology. Wind turbine operations and maintenance is one industry that is well-positioned to benefit in the near term from drone use in their operations.

WIND ENERGY AND DRONES ARE AN EASY FIT

The primary purpose of any drone is to carry cameras and other sensors to places that are challenging (economically or physically) to access. In the wind sector, blade inspection operations benefit tremendously from drone use. Instead of up-tower or ground-based inspection methods, a drone-based blade inspection involves a drone carrying a high-definition camera along each of the four sides of each of the three blades on a given tower. A technician conducting a blade inspection with a drone will typically find it most efficient to examine the images after an inspection flight. However, video and data-streaming products also make it quite simple to view the pictures or video on a mobile device in real time.

While pictures and video are most prevalent in terms of output from a drone inspection, drones are not limited to carrying cameras alone. Other sensors such as thermal cameras, ultrasonic sensors, and laser scanners are also useful in wind turbine blade inspections and can readily be configured to be carried and controlled by a drone. In fact, the type and variety of sensors that may be carried by a drone are limited only by its payload and, if applicable, its power storage and distribution capabilities.

HOW TO STAY SAFE WHEN IT COMES TO DRONES

Safety is a primary concern for any operation in the wind energy sector. Drones are a new technology that come with their own set of hazards, as well as features and processes to mitigate these respective risks. It's important for a drone operator to be familiar with these drone safety technologies and general aviation safety guidelines, in addition to all aspects of turbine inspection safety.

Anti-collision is a hot topic in the drone industry. As one might expect, anti-collision technologies prevent collisions, typically in the context of preventing collisions with things that the drone can see or observe using some sort of sensing technology. Sensors such as laser range finders or sonar are well-suited for identifying and avoiding wind turbines. Vision-based systems and radar, on the other hand, are better suited for detecting and avoiding other aircraft. There are a limited number of off-the-shelf drones that come equipped with these types of technologies; however, see-and-avoid sensing solutions will likely become standard with any off-the-shelf commercial drone purchase in the near future.


All photos courtesy of SkySpecs

A technology known as "geo-fencing" keeps a drone within global positioning systems (GPS) boundaries prescribed by the user or as mandated by air traffic control laws. Some implementations of this technology allow the user to define no-entry zones in the exact same way as one would define a no-exit zone. Technologies like this can be used, for example, to demarcate an area surrounding a wind turbine where the drone should not go inside. Geo-fencing is a complement and not a replacement for see-and-avoid. For example, imagine that your eyes are closed and that someone has asked you to take a picture at the edge of a cliff, which you're told is 10 yards away from you. This scenario is like trying to do an inspection with geo-fencing alone. In the example of taking a picture at the edge of a cliff, you would probably be comfortable taking six or seven steps forward, but

ALSO IN THIS SECTION

after that, it's probably not safe for you to proceed. See-and-avoid is the equivalent of opening your eyes. Just as opening your eyes gives you the ability to take those last few steps, so too does see-and-avoid allow the drone to get as close to a wind turbine blade as is safely possible.

THE BUZZ ABOUT AUTONOMY

Autonomy, for better or worse, has become a marketing buzzword in the drone technology sector. The word autonomy can mean anything from autonomous stability control to full-fledged automated surveys or inspections. As a prospective buyer, this can be confusing.

Most commercial drones navigate throughout the world with GPS. For many of these drones, onboard software allows the drone to follow coordinates, or waypoints, that are defined by the user using Google Maps or a similar application. This mode of autonomous navigation is convenient for surveying large areas or any kind of flight plan where the waypoints are spaced far apart. High-precision navigation tasks like wind turbine blade inspection have different requirements both in terms of user input and navigation techniques.

Navigation solely based on GPS falls short in the same way as geo-fencing. After all, they are based on the same underlying GPS technology. Advanced techniques that take input from multiple sensors beyond just GPS have come to the forefront as early adopters of drone technology in the wind energy sector begin to identify and adjust for the shortcomings of GPS. Combining multiple sensor inputs to achieve a unified understanding of the world and a robot's place within it is commonly referred to as sensor fusion. One example of a sensor fusion-based approach to navigation might involve the robot using GPS to make a guess at where the robot is located in the world, and then use a camera to hone in on its precise location. Humans regularly employ this type of approach to navigation. Any time you've ever been lost in a new city and come to a familiar intersection, your whole understanding of where you are falls into place. Visual cues can help both humans and drones navigate in this manner.

ROOM FOR GROWTH

Drones are an affordable and efficient means for collecting wind turbine blade inspection data, but what their use implies for preventative maintenance is perhaps even more exciting. Conveniently, drones generally "know" where they are located when they take a picture or collect some other piece of data. This makes it trivial to query pictures from the exact same location on the same blade over the past several inspections to see, for example, how a crack is progressing through time. Also, because drone inspections can be completed faster than manual inspections, and some day without

human supervision, the sheer quantity of inspection data that will be available will be a launchpad for new approaches to analytics.

A STRONGER, CLEANER STEEL FOR APPLICATIONS IN WIND TURBINES

By Patrik Ölund

As demand for renewable energy grows and wind turbines become an ever-increasingly common sight, the nature of their application is forcing engineers to look for steels with exceptional properties to meet the extreme demands placed on components in wind turbines.

High-performance steel is used for fasteners to hold wind turbines to the ground, to assemble the modules of the tower, and to attach the blades. Steel bar is used to make the anchor chains in offshore applications, while steel tube and bar is used for cylinders, pistons, and pumps that control slewing and pitch. Tube, bar, and rolled rings are used for bearings, gears, shafts, and couplings.

These components are expected to perform continuously in remote locations and in some of the harshest environments. They have to cope with the power and unpredictability of the wind, which creates high, multi-directional transient loads as wind speed and direction change, in addition to the massive cost of downtime if components fail.

Steel of very high cleanliness with a consistent microstructure and high resistance to fatigue and impact can be produced by advanced re-melting techniques, but the lengthy and complex processes involved — decarburization, vacuum induction melting, and vacuum arc re-melting — are expensive and have limited availability. However, advances in ladle metallurgy and testing procedures are now making it possible to produce low alloy air-melt steels that can compete with re-melt steels in terms of fatigue strength. With fatigue accounting for approximately 90 percent of all mechanical service failures, the potential benefits to the wind power industry are considerable.

THE INFLUENCE OF INCLUSIONS

It is well-known that the intrinsic fatigue limit of steel increases with the strength or hardness of the steel by a factor of approximately 1.6. However, as the strength of the steel increases, the obtained fatigue limit is increasingly lower than the intrinsic limit. This is the result of material defects, such as inclusions, acting as stress raisers and promoting fatigue crack initiation (see Figure 1).

In rotating beam fatigue tests, inclusions found at the sites where fatigue was initiated were analyzed for chemical composition, size, and location. The results were used to construct the empirical curves as shown in Figure 2. This shows that higher-strength steels are more affected by the presence of inclusions. Steel with an intrinsic strength of 640 MPa (400 HV) will not show any further improvement in fatigue strength once oxide inclusions are less than 20 µm. However, there is much greater potential for higher-strength steels to be improved and to get closer to the steel's intrinsic strength. For a steel with an intrinsic strength of 1120 MPa (700 HV), the critical inclusion size is just 6 µm.

LOADING DIRECTION AND VOLUME

Steel is typically anisotropic, so its fatigue strength will vary depending on the loading axis. This is exaggerated by the rolling process, during which inclusions are crushed and elongated in the direction of rolling (see Figure 3). The loaded volume also influences the likelihood of finding an inclusion of critical

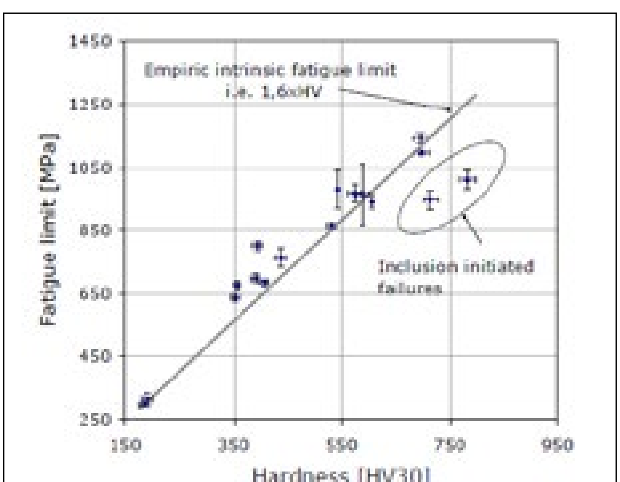


Figure 1: Fatigue limit defined as 107 cycles on rotating bending fatigue samples versus hardness.

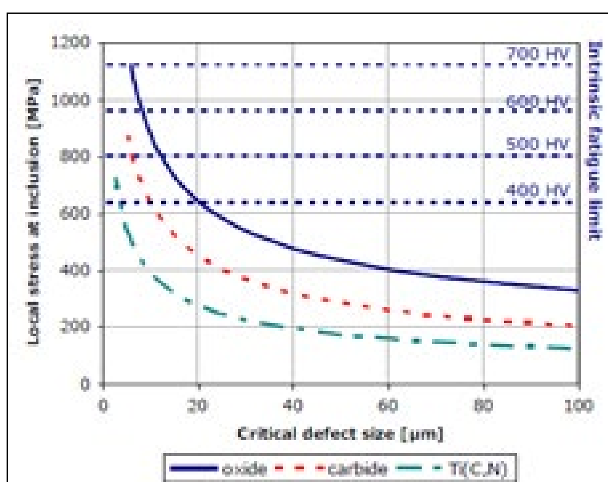


Figure 2: Expected applied stress that will cause a fatigue failure versus the critical defect size (equivalent circular diameter).

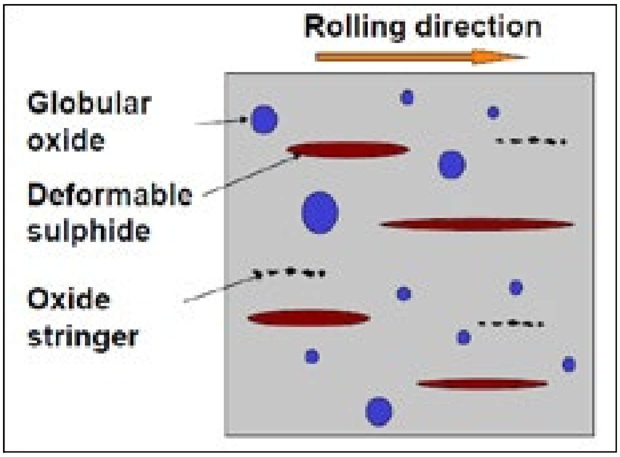


Figure 3: Schematic model of a conventionally processed steel with inclusions elongated in the rolling direction and with globular undeformable oxides.

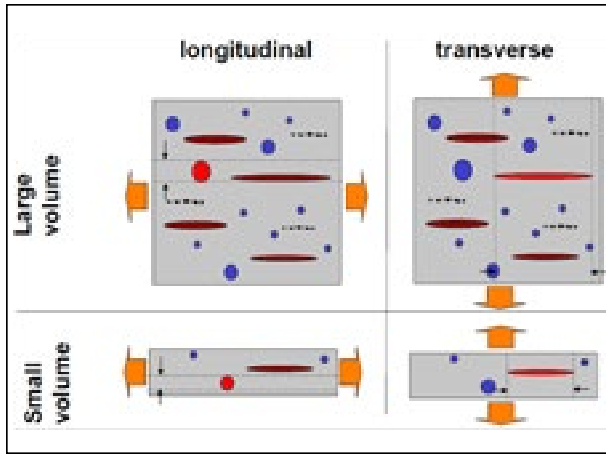


Figure 4: Influence of the loading direction and volume on the maximum projected area of an inclusion in the loaded volume.

size, therefore, a large volume that's loaded transversely to the rolling direction has a much higher probability of failure (see Figure 4).

Using current technologies, data can be collected on a material's morphology, chemical composition, and the position of inclusions. This data can be used to calculate the probability of finding inclusions of a certain size. Using the empirical relationship established in Figure 2, it is then possible to convert the inclusion size into the stress required to cause a fatigue failure.

Using this methodology, analysis of sulphide inclusions in a 100 m3 volume of high sulphur 50CrMo4 steel, loaded in the direction of rolling, shows a 5-percent failure rate at a stress of 800 MPa. When the loading is transverse to the rolling direction, 5 percent will fail at a stress of 200 MPa.

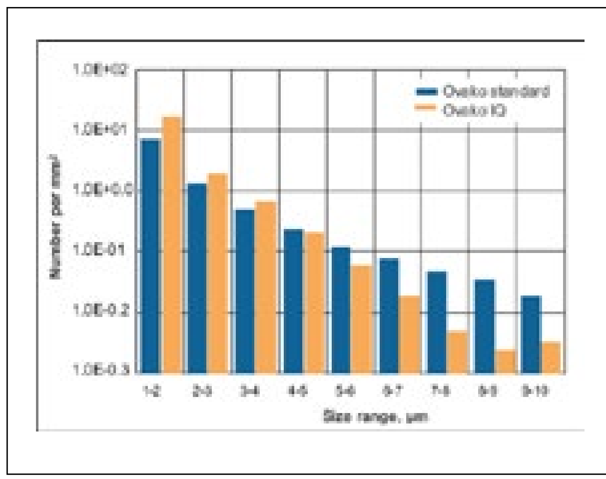


Figure 5: The graph shows the distribution of small inclusions in IQ-processed steel compared to conventionally processed low-sulphur, ball-bearing steel. The test dimension was a 90 mm steel bar.

ISOTROPIC QUALITY PROCESS

This ability to quantify the inclusion population in standard steels has enabled Ovako AB, a leading European producer of engineering steel for the bearing, transport, and manufacturing industries, to make dramatic improvements in the steel-making process and to introduce new processes that are capable of producing steels that can match re-melt quality.

The isotropic quality (IQ) process is based on Ovako's standard ingot casting process for the production of bearing quality steel, and it has two key objectives — to improve structural fatigue properties and to produce a more isotropic steel.

The key differences in the process are in the selection of scrap and raw materials, increased desulphurization (down below 20 ppm), increased degassing time, the use of argon shrouding during ingot casting, increased soaking time to improve homogenization, and increased crop-off mass in bil-

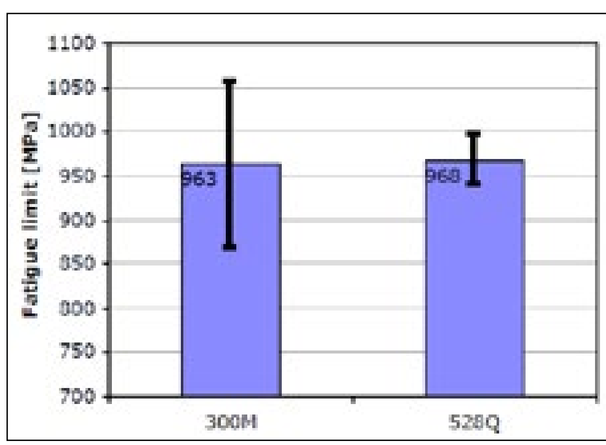
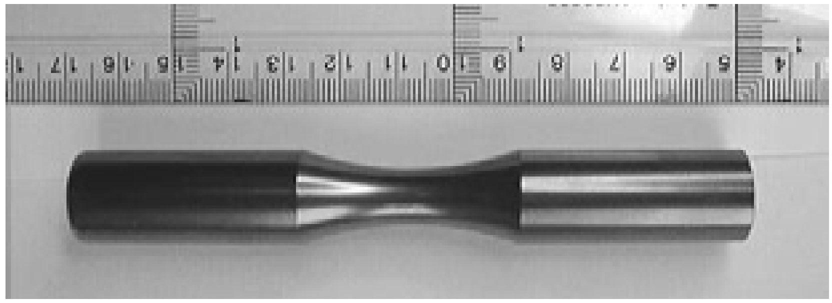


Figure 6: The graph shows the fatigue properties of an IQ-processed steel (528Q) compared to a steel produced through vacuum arc re-melting.

let production to reduce segregation and minimize the number of macro inclusions.

The IQ process does not remove the oxide inclusions, but based on the influence of inclusion size on fatigue, it creates a much finer distribution so that the number of inclusions below 4 µm is higher than in conventionally produced steel (see Figure 5). Inclusions that are smaller than 4 µm would require a very high stress to cause a fatigue failure (close to the intrinsic strength of the steel itself).

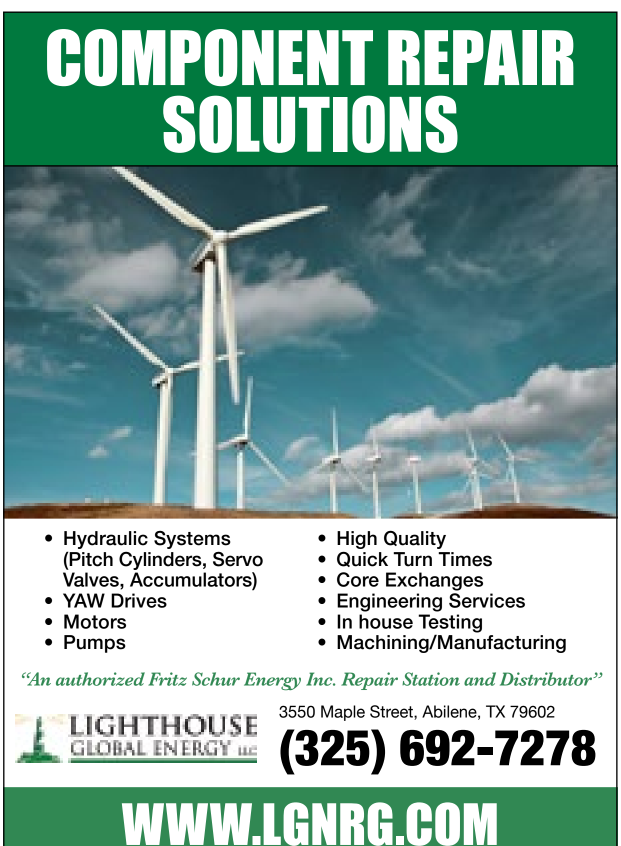
In rotating beam fatigue tests, the fatigue life of IQ-processed steel was found to increase by a factor of 10 over conventionally processed steel. When compared to a 300M steel (a low-alloy steel of very high strength) produced through vacuum arc re-melting (VAR), the determined fatigue limit and the size of inclusions that initiated fatigue failures were almost identical (see Figure 6).


A test sample for a rotating beam fatigue test.

In order to measure improvements in isotropy, a conventionally produced 50CrMo4 steel was compared to an IQ-processed variant. In each case, billets were cross-rolled into a plate from which samples were machined, orientated both longitudinally and transversely to the initial rolling direction.

While the IQ-processed steel showed virtually no difference in fatigue limit between the longitudinal and transverse samples, the conventional steel could only achieve half the fatigue limit when loaded into the transverse direction.

Selection of suitable clean steel produced through advanced ladle technology offers the desired fatigue strength for use in wind turbine applications. When making material selection for use in such demanding applications, detailed knowledge — not only of the magnitude of the applied stress, but also in loading direction and loaded volume — is crucial.



RENEWABLE NRG AND VENTUS INSTALL WIND IRIS LIDAR AT FIRST URUGUAYAN WIND FARM

Renewable NRG Systems (RNRG) and Ventus Ingenieria recently announced the acquisition and installation of a Wind Iris nacelle-mounted Lidar at the 20-MW Caracoles wind farm in Uruguay. The Wind Iris will monitor turbine performance and offer optimization solutions for the project.


Renewable NRG Systems

Located in the Sierra de Caracoles in the Maldonado region of the country, the project is composed of 10 Vestas V80 2-MW turbines. The wind farm is owned by UTE, Uruguay's national utility and electricity market regulator. UTE has the monopoly over all distribution and transmission activities across the country. It is also the off-taker of all private wind farms with private purchase agreements (PPAs).

The measurement campaign's objective is to evaluate and quantify the performance of one specific turbine with state-of-the-art Lidar technology and to propose solutions to improve the energy production. Based on the results reported by RNRG and Ventus, UTE will evaluate the success of the campaign and make a decision regarding the potential performance evaluation of the other wind turbines in the fleet.

Commissioned in 2010, Caracoles is the first wind farm commissioned in Uruguay. Since then, the country experienced a spectacular wind energy boom. With 850 MW already operating and more than 650 MW set to be installed in the next 12 months, Uruguay is taking a leading position in South America's energy transition.

"Uruguay has set a very ambitious national target for wind power," said Evan Osler, Sr., the technical lead for remote sensing at RNRG. "The country is on its way to achieving a staggering 45 percent wind penetration by the beginning of 2017. The installation of this first Wind Iris in Latin America demonstrates the Uruguayan market maturity in benchmarking turbine performance and maximizing AEP with cutting-edge measurement technology."

Caracoles presents moderately complex terrain and ambient turbine wakes, which means that proper filtering and data treatment is critical. Fortunately, the Wind Iris yaw correction algorithm has already been validated in both waked and complex wind flow conditions — making it a strong fit for the job at hand.

"We offer independent performance evaluation packages to our clients, and to that purpose, Wind Iris is the best tool to get the job done," said Juan Pablo Saltre, founding partner of Ventus. "From our clients' perspective, the most important advantage of using Wind Iris is that the ROI of these campaigns is easily quantifiable using the standard equations and real data."

Source: Renewable NRG Systems

For more information, go to www.renewablenrgsystems.com.

AWS TRUEPOWER ACQUIRES ENERGY-RELATED FORECASTING ASSETS FROM MESO INC.

AWS Truepower, an international leader in wind and solar energy consulting and engineering services, recently announced that it has acquired the energy-related forecasting assets of Meso, Inc., their long-term partner in renewable energy forecasting and grid services.

Meso, a founding partner of the former TrueWind Solutions, and AWS Truepower have collaborated for years in providing wind and solar power forecasting services to the utility and renewable energy industries around the world. Major clients include the California ISO, ERCOT, Hawaiian Electric, New York ISO, Ontario IESO, E.ON, and Enel. Thanks to this partnership, AWS Truepower has become the top wind and solar forecaster in North America with forecasts being provided for over 50,000 MW of capacity.

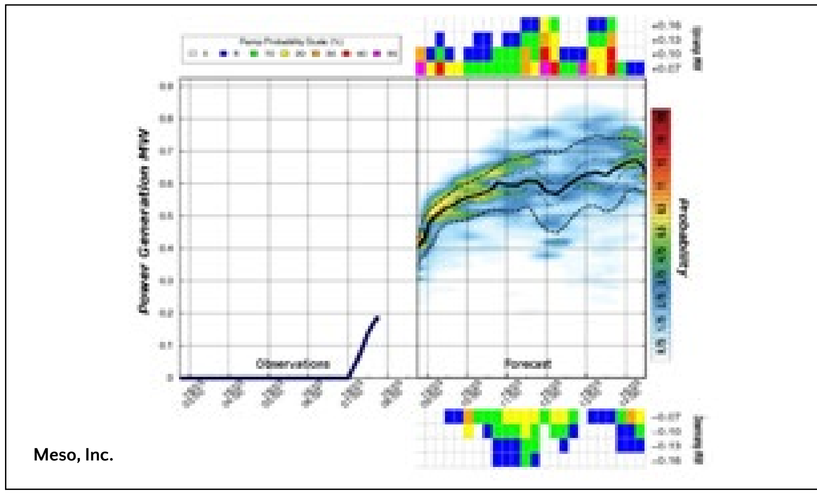
Meso and AWS Truepower have also worked closely together on numerous ground-breaking research projects around forecasting and grid integration, and Meso has provided key support for the development of AWS Truepower's wind mapping and modeling systems, which continue to lead the industry in accuracy.

"By joining together, we expect to achieve even more success in the future," said Bruce Bailey, CEO of AWS Truepower. "This move consolidates the Meso and AWS Truepower operations, enabling us to serve our clients more effectively and positioning us to invest in new markets for forecasting and other grid solutions."

Meso's staff joined AWS Truepower as part of the company's Grid Solutions business unit. John Zack, president of Meso, will lead the new unit as vice president for Grid Solutions.

Source: AWS Truepower

For more information, go to www.awstruepower.com.



Meso, Inc.

Meso uses numerical weather prediction (NWP) model data, observations, and production data from wind or solar generation facilities as inputs into several statistical models that adjust the forecasts for specific locations.

ALLIANZ RISK TRANSFER AND PARTNERS DEVELOP SWAP SOLUTION TO HEDGE VOLATILE REVENUES OF WIND FARMS

Allianz Risk Transfer Limited (ART) and partners have developed an innovative risk management solution for hedging wind volume risks for wind farms. ART has executed a 10-year proxy revenue swap with Capital Power's Bloom Wind Farm, which will be constructed near Dodge City, Kansas.

This new risk management tool for the wind energy industry was created and commercialized through a partnership among ART, Nephila Capital Limited, REsurety, Inc., and Altenex, LLC. The 10-year agreement will secure long-term predictable revenues and mitigate power generation volume uncertainty related to wind resources for the 178-MW Bloom Wind Farm.

"This new product line for the wind power industry will enable more efficient and cost-effective financing of wind generation projects," said Karsten Berlage, managing director of ART. "Due to the high upfront costs of modern utility-scale wind projects, it is important for investors in such projects to be able to secure long-term stable revenues to underpin the investment."

Traditionally, price-focused hedging solutions have been commonly used to try to address this, but this newly created proxy revenue swap offers an entirely new form of revenue risk management for the wind power industry. Similar in concept to a tolling agreement or capacity payment, this novel structure swaps the floating revenues of a wind farm — those driven by the hourly wind resource and power prices — for a fixed annual payment. This transaction

Allianz Risk Transfer Limited / Shutterstock is the first in a robust pipeline of future wind financings and would also be feasible in other wind farm markets globally beyond the United States.

The ART-led swap is unique in several aspects. According to Berlage, recent advances in data availability for the U.S. wind market as well as in risk assessment and modeling allowed this unprecedented scope of risk transfer within a single product, which is available for up to 10 years.

"In contrast to more short-term and price-focused hedging approaches, for the first time, price and wind volume risks of a wind farm have been managed at the tenor needed to support a project's capital structure and balance sheet," Berlage said. "The result is a level of revenue certainty never before available to the wind industry."

Each partner contributed highly specialized expertise to create this innovative swap solution. ART and Nephila leveraged their collective weather risk transfer expertise, risk capacity, underwriting sophistication, and credit strength. REsurety has provided the specialized risk analyses relied upon for the structuring of the proxy revenue swap and delivers ongoing services as the calculation agent for the transaction. Altenex supports the management of power price-linked risk as part of the proxy revenue swap structure.

ART and Nephila have a long-standing partnership in the weather and catastrophe risk markets and have worked with REsurety since 2012 to develop risk transfer products for the wind power industry. More recently, through a partnership established between REsurety and Altenex in 2015, protection against low wind output has been expanded to include power price risk as well as generation volume-linked risk exposures.

Source: Allianz Risk Transfer

For more information,
go to www.agcs.allianz.com.

CYBERHAWK COMPLETES ROAV INSPECTIONS FOR FOREWIND'S DOGGER BANK METEOROLOGICAL MASTS

Cyberhawk Innovations, a world leader in remotely operated aerial vehicle (ROAV) inspection and survey, recently completed an operation and maintenance inspection project on Forewind's Dogger Bank meteorological masts using ROAVs.

The project required a team of three from Cyberhawk, including offshore ROAV pilots and a mechanical engineer, mobilize to the Round 3 development site to undertake ROAV inspections of the two meteorological masts. Dogger Bank is a particularly challenging offshore wind farm site because it is the furthest offshore wind project from United Kingdom shores at approximately 150 kilometers from the U.K. coast.

The inspections took just one day per met mast, which represents a dramatic time saving in comparison with traditional methods that could take at least double the time. The use of ROAV also significantly improved safety levels by reducing the requirement for personnel to climb the towers and work at great heights.

"We were delighted with this contract award as it demonstrated Forewind's confidence in our capabilities and experience, having successfully completed previous projects with the consortium," said Philip Buchan, commercial director at Cyberhawk. "Once again, our inspection solution has proven that professionally operated ROAV can capture equal, if not more, detailed results than sending in personnel."

According to Buchan, the safety benefits come hand-in-hand with reduced costs and quicker inspection time, all of which are being increasingly recognized by wind farm operators both onshore and offshore.

"Cyberhawk continues to demonstrate how ROAV can be safely and effectively used to carry out inspection work in the offshore wind sector," said Forewind's safety manager Nachaat Tahmaz. "We were extremely pleased with the inspection completed and in the quality of the detailed report provided."

Source: Cyberhawk Innovations

For more information,
go to www.thecyberhawk.com.


Cyberhawk