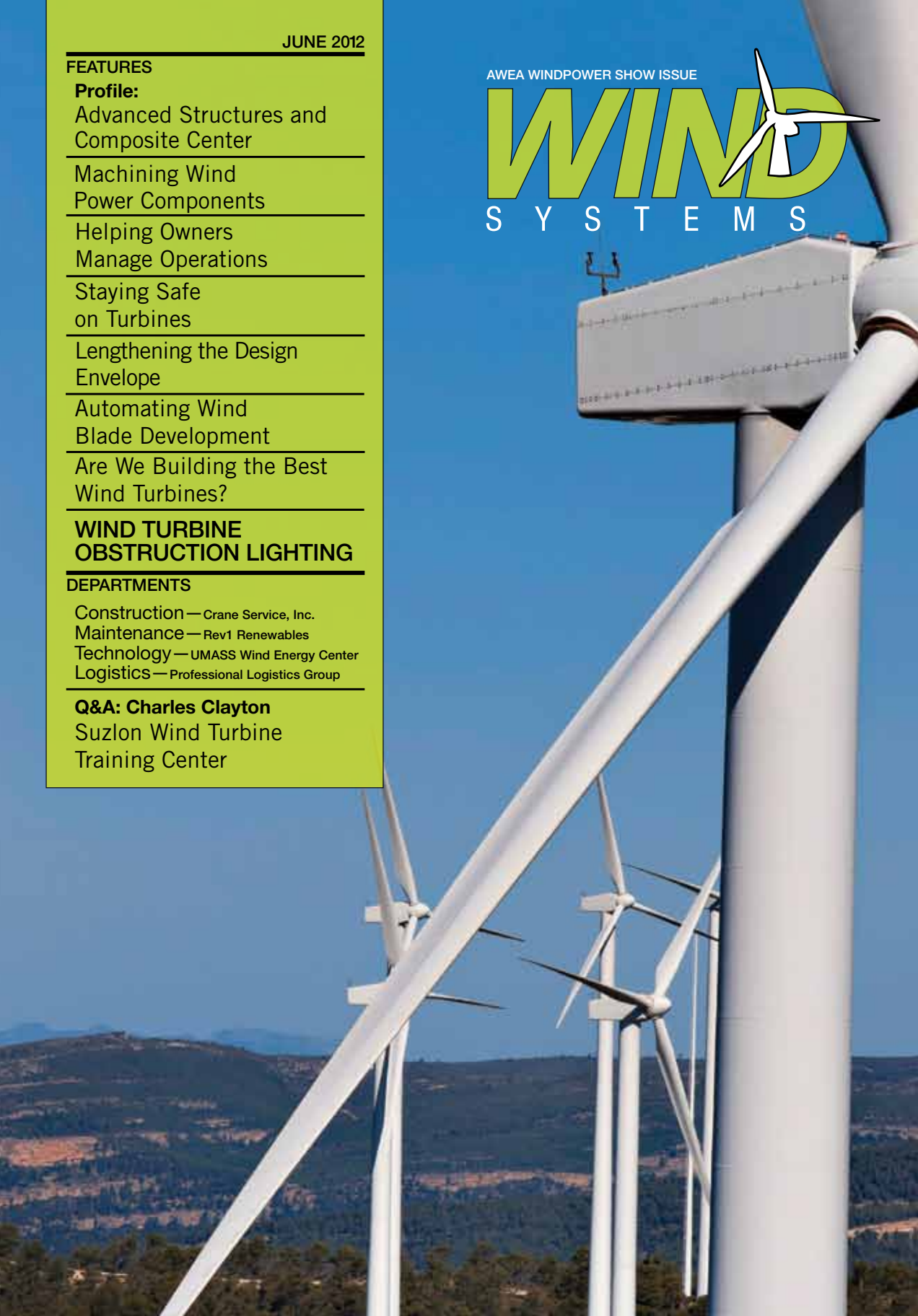
JUNE 2012

AWEA WINDPOWER SHOW ISSUE

WIND SYSTEMS

FEATURES

DEPARTMENTS



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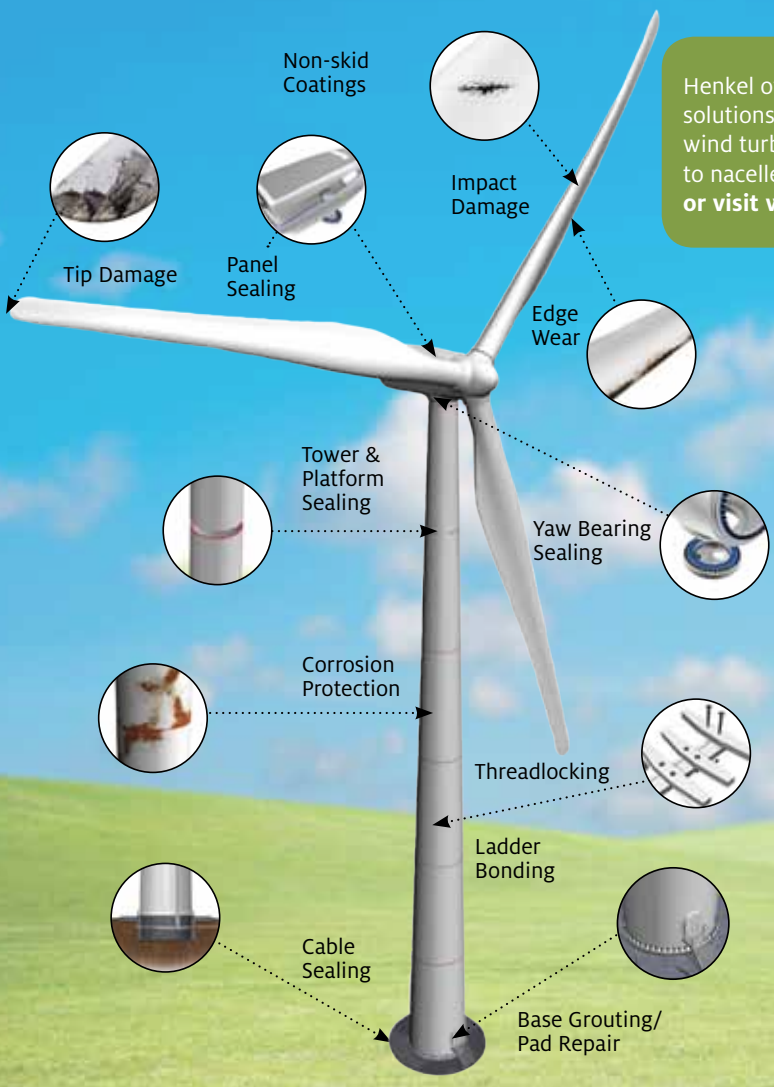

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RESOURCES

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EDLETTER

Change is opportunity. I've heard that many times. Change opens the doors for fresh ideas and energy. Change is also difficult at times, but as Winston Churchill once said, "A pessimist sees difficulty in every opportunity. An optimist sees opportunity in every difficulty."

As many of you already know, Wind Systems editor, Russ Willcutt, is no longer with the company. After nine years as editor with Media Solutions, Inc., Russ has moved to a new company to pursue his interests in the medical field. We appreciate his dedication to the publication and wish him well in his new pursuits.

As I assume the role of managing editor with Wind Systems magazine, I hope to earn your respect and friendship. I look forward to developing relationships with new people and spending more time with some old friends.

A little about me: I don't know when the journalism bug bit me, but anyone who knows me will tell you that I bleed ink. I like the smell of the ink. I like the whirl of the presses. I'm one of those old school newspaper girls who think direct-to-plate printing is wonderful, but I'd still like to hold a negative and hear the pop of the metal as I lift it up.I spent many years in the newspaper business around the Southeast, doing everything from investigative reporting to running the whole show as editor with several large and small dailies and weeklies. About 15 years ago I crossed over to consumer magazines and then business-to-business publications in the construction and trucking industries.

Back then, I didn't know a thing about trucks or construction, but I learned quickly and discovered a passion for both. I know with a little time, I'll feel just as comfortable in the wind energy business. I've already attended my first technical event and will soon be in Atlanta at the Wind Power Show where I'll be cramming my brain full of knowledge and exchanging business cards to plug into my contact manager software.

You're holding (or scrolling online) our annual AWEA Wind Power Show issue. I hope you'll take time to read through the articles and departments and find something of interest to you.

In this issue were featuring International Tower Lighting, LLC. When ITL engineers designed their wind turbine lighting system, they surpassed FAA requirements and built a unique product specifically for the wind turbine industry. This company impressed me with their attention to detail and design processes.

For my contribution, I learned about the Advanced Structures and Composites Center at the University of Maine in Orono. This facility has the manpower and resources to test blades measuring 230 feet in the largest facility available in the United States. The center also is home to one of only two facilities in the world with high quality wind and wave scale model testing of fixed or floating offshore wind turbines.

Stop by our booth #6213 and say hello while you're at the Wind Power Show. I look forward to hearing your ideas and suggestions on how we may make *Wind Systems* even better.

Sherri Mabry, editor
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CAPITAL SAFETY GIVES AWAY EXOFIT NEX™ HARNESS AT WINDPOWER 2012

One lucky person has a chance to win an ExoFit NEX Global Wind Energy Harness from Capital Safety at AWEA Windpower 2012.

The harnesses were developed specifically for the needs of the global wind energy market. With a convenient radio and Lad-Saf® sleeve holster on the front of the harness and removable tool loops on the belt, this harness allows the user to easily carry equipment on their harness while climbing a tower. The construction model utilizes a removable lumbar protector that helps prevent wear and tear on the belt and back pad. Its ability to be replaced with accessory protectors prolongs the harness' life. Stamped with ANSI, CSA and CE approvals this harness can be taken to worksites across the globe and be in compliance with appropriate standards.

The harness is constructed with aluminum front, back and side D-rings, locking quick-connect buckles and a sewn-in hip pad with belt and lumbar wear protection. The harness is available in XLarge, Large, Medium and Small. A medium size model will be on display at the *Wind Systems* booth #6213. A fitted harness will be mailed to the winner after the show.

MASSIVE TEST FACILITY FOR WIND TURBINES TAKING SHAPE

Clemson University and its partners in South Carolina is pouring concrete for the first of two foundations that will house the world's largest wind turbine drivetrain testing stands.

Choate Construction is building the $98 million facility at what is now part of the Clemson University Restoration Institute.The concrete foundation will form the base of the stand that will allow full-scale highly-accelerated testing of advanced drivetrain systems up to 7.5MW with 50Hz and 60Hz capabilities. It is scheduled to be operational in early 2013. The second test stand that will be able to accommodate next generation wind turbine drive trains up to 15MW will begin operation in spring next year.

Companies wishing to submit materials for inclusion in this section should contact Sherri Mabry at sherri@windsystemsmag.com. Releases accompanied by color images will be given first consideration.

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INA FAG

The US Energy Department in November 2009 awarded a $45 million grant to the Clemson-led group under the American Recovery and Reinvestment Act to help build and operate the project. South Carolina and private donors provided the about $53 million in matching funds.

Clemson's public partners are the State of South Carolina, South Carolina Commerce Department, South Carolina Public Railways, South Carolina State Ports Authority and the Charleston Naval Complex Redevelopment Authority.

The site is adjacent to existing rail and dockside infrastructure, essential for handling the heavy components.

University officials estimate the drive train testing center will create as many as 800 direct and indirect high-paying professional jobs.

SANDIA ANNOUNCES CONSTRUCTION ON TEXAS WIND TURBINE RESEARCH FACILITY

Sandia National Laboratories and its academic and private partners expect to have a state-of-the art wind turbine research facility in operation in October in Lubbock, Texas.

The first phase of Scales Wind Farm Technology Facility (SWIFT) is being constructed in partnership with Texas Tech University in Lubbock, Vestas and Group NIRE, a renewable energy development company.

The US Energy Department's Office of Energy Efficiency and Renewable Energy is funding Sandia's work, which will allow the use of the site for research.

Studies at the facility will initially focus on turbine-to-turbine interactions and innovative rotor technologies. Other areas for investigation include aero-acoustics and structural health monitoring of turbines using embedded sensor systems.

The SWIFT concept reflects a shared emphasis among the partners on lowering the cost of wind energy by maximizing the output of a wind farm rather than a single turbine.

The site will initially use three Vestas 300kW V27 turbines, which are smaller than utility-scale turbines. Sandia worked with Vestas to develop the site plan, uniquely tailored to study turbine-to-turbine interactions.

The site might eventually expand to include nine or more wind turbines, allowing researchers to learn how

individual turbines and wind farms can integrate better with the grid.

NEW HIPER-TEX™ W3030 ROVING INTRODUCED

Engineered specifically for polyester or vinylester resin systems, HiPer-tex™ W3030 roving also allows for longer, lighter blades for both offshore and onshore wind turbines.

3B is launching HiPer-tex™ W3030 high performance roving – the third product in the company's series of innovative solutions for wind turbine rotor blades.

Specifically developed and engineered for polyester and vinylester resin systems and for resin infusion processes, HiPer-tex™ W3030 roving provides yet another novel option which allows OEMs to manufacture longer and lighter blades for the larger multi-megawatt wind turbines located both onshore and offshore.

3B, HiPer-tex™ W3030 rovings combine high performance glass properties and enhanced sizing compatibility with unsaturated polyester and vinylester resin systems. This new roving provides optimum properties for rotor blades created with lower cost resin systems and therefore helps blade manufacturers narrow the gap with higher cost, alternative composite solutions.

The new roving offers up to 10% weight saving for the same design and length when comparing rotor blades manufactured with traditional E-glass. In addition, the turbine blade span can be lengthened by up to 6% while still maintaining the same weight though contributing up to 12% more energy output.

A more consistent laminate quality is achieved as HiPer-tex™ W3030 roving offers better wet-out. Higher shear strength and substantially greater interfibre strength and excellent fatigue performance is provided by the significantly improved resin matrix adhesion when compared with existing high modulus fiberglass in the market place.

3B's technological expertise and manufacturing know-how delivers reliable, high performance, sustainable and cost-competitive solutions for wind energy applications especially designed for the challenging and bigger multi-megawatt turbine blades, according to the manufacturer.

Other recently launched products in 3B's rovings products for wind turbine blades include HiPer-tex™ W2020 and SE2020 made with Advantex® glass, both specifically designed and engineered for

epoxy resin systems used in resin infusion or prepreg processes.

TESTS CONFIRM INCREASED ENERGY GENERATION

During the the last few months the Evance R9000 small wind turbine has undergone further tests which have confirmed its energy generation has increased by over 4% to 9,167kWh at a wind speed of 5 metres per second.

The R9000 small wind turbine was one of the first small wind turbines to achieve SWCC conditional certification last year, and has received further improvements since.

Many Evance customers have already benefitted from higher than expected energy generation as the R9000 system improvements were implemented several months ago. For example, Clive Breeze was pleasantly surprised with the energy generated from his recent installation: "In the first three weeks alone, the R9000 turbines exceeded the predicted energy generation targets by 10 percent." This reduced the customer's first quarterly electricity bill by the equivalent of nearly $500.

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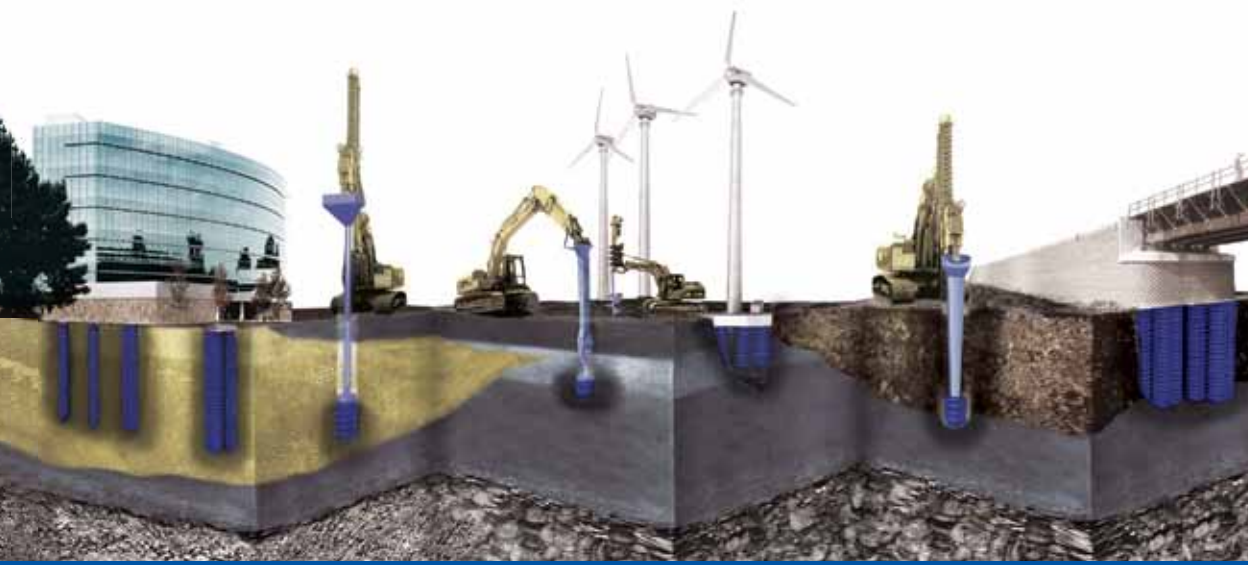

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"We're delighted that our R9000 turbine is proving so efficient in energy production as this translates directly into a faster return on investment for our customers," said Kevin Parslow, CEO of Evance Wind Turbines. "Our R9000 machine accounted for a third of all small wind turbines sold in the UK last year – making it the UK's small wind turbine of choice. We look forward to accelerating our drive into the North American market though our network of installers in a bid to establish a similar market leadership position," concludes Kevin. For more information, visit www.evancewind.com.

PLACEMENT SYSTEM SPECIFICALLY DESIGNED FOR INSTALLATION OF ALL-DIELECTRIC/SELF-SUPPORT CABLE

Known for rugged and dependable outside plant cable installation tools and equipment, the General Machine Products Company, Inc. (GMP), Trevose, PA, is pleased to introduce the All-Dielectric/Self-Support Cable Placement System to its line of aerial cable placement solutions. The All-Dielectric/Self-Support (ADSS) Cable Placement System provides specialized equipment necessary for aerial installation of nonconductive, high-strength fiber optic ADSS cable over short, medium and long span distances.

As its name indicates, All-Dielectric/Self-Supporting cable requires no messenger wire for support. Therefore, placement is achieved in a single pass, making ADSS cable an easy and economical way to install a fiber optic network. This type of installation can also be a solution in an aerial environment where power cables are close by, or where a lashing operation is impossible due to the proximity of other cables on the poles.

Because ADSS cable can be deployed in a variety of tough environmental and electrical conditions, components that make up the All-Dielectric/Self-Support Cable Placement System are specifically designed to meet the challenges work crews face.

The Cable Pony Trailer Mounted Winch uses grooved, double bull wheels to provide superior handling of the pulling rope, while providing a constant tension with a maximum capacity of up to 2,200 lbs. (1,000 kgs). The winch can offer line pulling speeds up to 130 ft. (40 M) per minute.

The ADSS Cable Placement System also includes a Payout Stand and Storage Reel. The Storage Reel has a capacity of 2,000 ft. (609.6 M) of 5/16 inch. (7.9 mm) diameter rope. It is uniquely designed to be compatible for mounting either on the Cable Pony Trailer Mounted Winch or the Payout Stand.

Two (2) sizes of In Line Blocks and three (3) sizes of Starter Blocks are also offered with our ADSS

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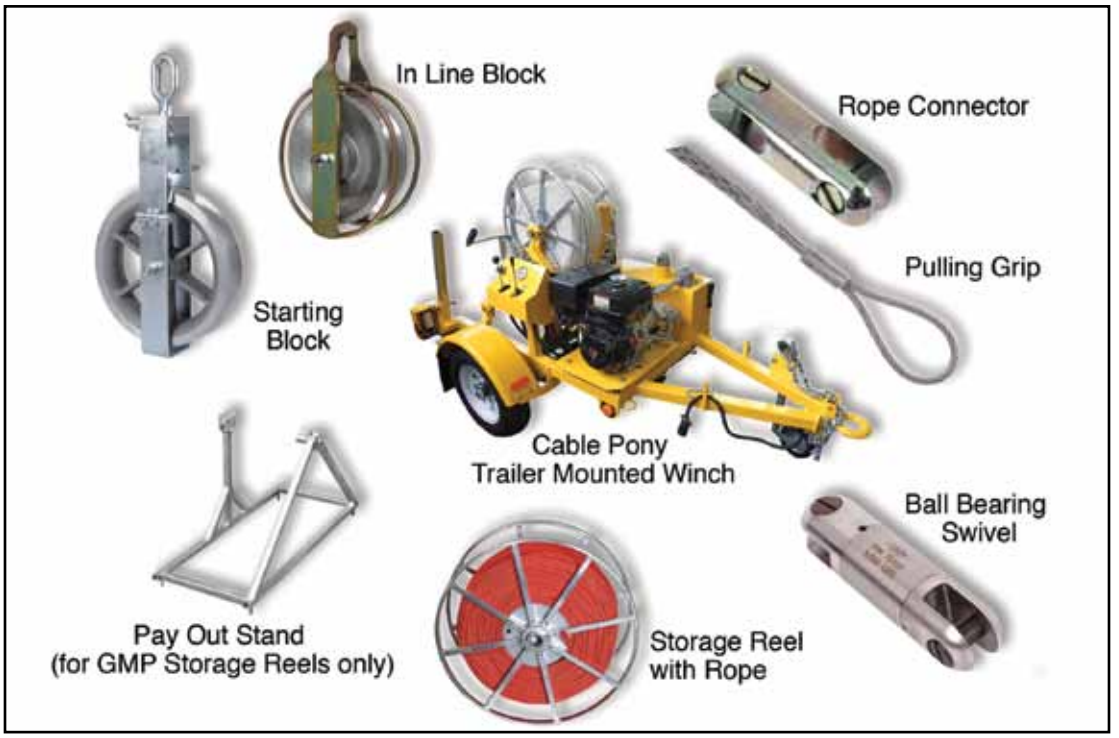
Cable Placement System. This variety of blocks will maintain the bending radius requirements for various cable diameters, load ratings, etc.For more information, visit GMPtools.com/nf/adss.htm, or by contact Ted Clemens at 215-357-5500; info@GMPtools.com.

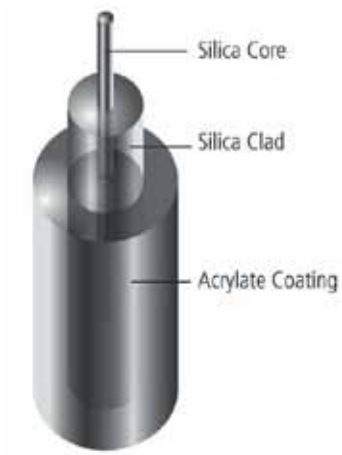


ACCUTETHER TM FIBER PERFORMANCE EXCELS IN PAYOUT, TETHER AND SENSING

OFS and its Specialty Photonics Division, a leading designer, manufacturer and supplier of innovative fiber optic network products, is please to announce commercial availability of Accutether™ fiber in both standard and reduced diameter sizes. This singlemode fiber features excellent bend performance and is ideal for defense applications where the fiber experiences tight bend, is permanently coiled or where a coil is designed to payout. Proof tested to 100 or 200 kpsi the fiber has high reliability and is available in long continuous lengths. The standard size fiber has a 245µm O.D. and the reduced diameter fiber features an 80 µm cladding and 160 µm O.D.

"A major advantage of this fiber is the excellent bend performance", says Cathy Ciardiello, Market Manager for OFS defense related business. "Macrobend attenuation at 1550nm induced by 50 turns around a 4mm mandrel is < 0.01dB. The tight dimensional control of geometric parameters helps ensure stability for consistent winding/ payout of coils", adds Ms. Ciardiello, and the dual acrylate coating system protects during deployment and lifetime. Accutether™ coils can be ordered directly from the OFS Specialty Photonics site in Broendby, Denmark.

For more information, please visit www.ofsoptics.com or wwwspecialtyphotonics.com.



SECOND WIND LAUNCHES WIND ENERGY OPERATIONS SERVICES

Second Wind announces the introduction of a suite of wind farm operations services based on the company's Triton® Sonic Wind Profiler and SkyServe® Wind Data Service. Triton, a remote sensing system using

sodar technology to provide wind measurements across the turbine rotor sweep, and SkyServe, a cloud-based data delivery tool, have already been widely adopted by wind farm developers for use in wind resource assessment.

"2011 was a big year for Second Wind as Triton and SkyServe continued to lead the global wind power development market for remote sensing," says Larry Letteney, CEO. "In addition, working in partnership with several large wind farm operators and utilities, we deployed a large number of Triton in support of wind farm operations."

Wind farms have a number of operating issues that can be explained and resolved based on thorough understanding of the wind conditions onsite. With the rapid global growth of wind energy and improvements in turbine technology, advanced wind information systems are needed to provide more comprehensive information about wind conditions. The applications for Triton on operating wind farms include:

- Complementing or replacing expensive hub height reference towers for operational support, compliance, power marketing, and improved wind forecasting;
- Mobile applications providing turbine performance, wake, and sector analysis;
- Complete wind farm assessment for warranty and financial purposes.

Second Wind recently expanded into a new 25,000 square-foot manufacturing facility near Boston to support the wind industry's growing demand for Triton.

Matt Hendrickson, senior director of energy assessment at 3TIER, says that "A well-qualified remote sensing system such as the Triton can be extremely valuable in assessing wind farm performance. Measuring the vertical structure of the wind profile and relating it to turbine efficiencies goes a long way in explaining varying production patterns. Used properly, this technology will ultimately increase the skill of one's predictive models."

Second Wind has been a global innovator in advanced technology for wind measurement since 1980. For more information visit www.secondwind.com.

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Continued on pg 74 >

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HIGHLAND COMMUNITY COLLEGE

Chris Martin
Crane Service, Inc.

Many factors play a role in successfully coordinating crane service for wind park maintenance.

IN THE PAST FEW MONTHS we have discussed crane rigging, types of cranes, and how to remove blades. This month we will be taking a step back and discussing the behind the scenes of wind park maintenance. Clients will ask if we can get the crane on-site in a few days or within a few hours. We always say yes and meet our promise. But dispatching a crane is not easy. It is actually quite a difficult process.

There are so many factors behind the scenes that determine when and how we get a crane on-site. Every day we are faced with different challenges; challenges that change daily due to employee locations, weather, previous and future crane jobs, and actual erection time.

Employee locations change all the time. We have drivers spread out all over the Southwest picking up and dropping loads off. With our Manitowoc model 16000 we need 18 truckloads to get the 500,000 lb. crane on-site. The coordination required to make this happen is immense. We have to coordinate with all of our branches to find the best and most efficient way to get the trailer loads to the site safely and on-time. This can get difficult, but we have an amazing dispatch team that makes sure we meet our deadlines.

Weather can play a big part in whether we can get on-site. Weather and storm systems can delay trucks because the roads cannot be traveled. Wind and storm systems can exist in areas where the model 16000 can be effective in wind corridors. We were recently going through tornado alley with our 18 loads, and needless to say, we had to slow things down and take more time to navigate the corridor. The roads that exist on wind parks and bluffs are not the best or easiest roads to maneuver. Any moisture can turn a dirt road into a challenging adventure. The roads aren't impossible to travel, but rather more difficult and time consuming for our crews.

Previous jobs or the next job can also set the tone of how we get a crane to a wind park. If we are taking down a gearbox we can utilize a wide variety of cranes, but we are limited logistically. There is no telling where a crane will be in any given day or hour. Things can change so fast that one minute we have cranes available and 10 minutes later they are all booked and getting prepared to leave. Where we excel is in our experienced dispatch team. They are able to keep our cranes moving in and out of wind parks effectively and on-time all while keeping them busy the rest of the day. As I stated in previous columns, we can be "winded out," which can further delay future projects within a wind park and outside. There are days when we are getting ready to leave the yard and get notification moments before we leave, that the wind has picked up and we are unable to work.

Crane erection time can be a challenge in wind parks, as well. When we are moving our crawlers, lattice boom truck cranes, or hydraulic cranes, the process or erection can vary. A typical hydraulic crane on a wind site may only take a few hours, but is limited to what parts it can hoist. The crawler crane can vary on erection time depending on which crawler we use. For our Manitowoc 2250, we can erect this model crane in as little as eight hours or it can take up to two to four days depending on other attachments we add to it, like the Max-er heavy lift attachment. For our Manitowoc model 16000 we can erect this crane in the same time frame as our 2250. Typically erection can take a day's worth of work. Although, as previously stated, a number of factors can affect erection times. Building a crane on a wind site can also be difficult due to the lack of room to erect the crane.

"If we are taking down a gearbox we can utilize a wide variety of cranes, but we are limited logistically."

Working in wind parks can be interesting and can keep our team of dispatchers busy. We are blessed to have a dedicated dispatch team that spans the Southwest. Having a team that not only works well with clients, but also is also highly skilled contributes to our success.

When our crawler cranes are moving at the rate they are – knowing the location is just as is crucial. In the grand scheme no one piece is more or less important than the other, but having an experienced dispatch team with more than 20 years experience means less time from call to delivery, which is beneficial to everybody.

Chris Martin is marketing coordinator at Crane Service, Inc. Learn more at www.craneserviceinc.com.

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Merritt Brown
Rev1 Power Services, Inc.

Where a gearbox oil sample is taken is just as important as how it is taken. As this second installment of a two-part series explains, it's all about obtaining the most evidence from the best possible location.

IN OUR PREVIOUS INSTALLMENT WE explained how wind technicians can use their physical senses to diagnose some common wind turbine gearbox problems while up tower. The color and smell of the oil, for example, can relate to such abnormal operating conditions as oil degradation, water emulsification, and solids entrapment. These properties can quickly tell a technician that an issue may be lurking and promote further investigation into a root cause. While these initial criteria can raise a red flag, laboratory testing of the oil provides an objective analysis of what is going on inside the gearbox. Lab testing will determine the particle count, amount of wear metals and contaminants, and measure the protective additives that remain in the oil. The industrial measure of viscosity, the Kinematic Viscosity at 40° C, is also tested as an indicator of how the oil is changing from its original grade- typically requiring a tolerance of 10% from the original specification. As viscosity changes with the amount of contaminants and wear metals, a trend on the Kinematic Viscosity will indicate a change over the sampling timeline while the Viscosity Index or the viscosity of the base oil, may actually remain unaffected.

It nearly goes without saying that where you take a sample is just as important as how the sample is taken. Without a representative sample of what is truly flowing through the gearbox, the laboratory tests might be inconsistent with the physical findings. For example, a sample taken after the filtering system can be absent of valuable data from the oil since filters are contaminant removers. Likewise, a sample drawn from the bottom of the gearbox may tend to show higher levels of debris and may not accurately represent the current condition of the unit. While each turbine manufacturer seems to have differing philosophies on where and how to sample the gearbox oil, the sample should be taken to ensure there is as much evidence as possible in each sample of oil.

Without argument, the best sampling location would be in a circulating system at a location downstream of wear components and before the filter system. Unfortunately, this is not how most wind turbine gearboxes are designed. Though it may be possible to independently operate the oil pump on some turbines to allow for a sample to be drawn while the oil is flowing, in many cases the turbine is shut down and has sat idle until the technician has climbed the tower to perform service work. This means that the oil has had time to settle and heavier particles begin to settle and stratify according to size and density, thereby compromising the quality of oil analysis.

More commonly, the gearbox is simply equipped with an oil sample valve and plug somewhere below the sump oil level. While this tap is probably the most prevalent oil sample location, using it to obtain a representative sample can have its drawbacks. Most significant is the fact that bottom sediment, debris and particles (including water) enter the bottle in concentrations that are not representative of what is experienced near or around the lubricated components. If it can be avoided, using the drain plug should be a method of last resort.

Although it is intrusive to the gearbox and exposes the system to potential contamination, a drop-tube vacuum sampling method can obtain a more representative sample on systems where operating a forced circulation system is not possible. Again, it is the technician's responsibility to ensure cleanliness of the oil whenever the gearbox is open, and this sampling method permits a tube to be inserted into the sump cavity where oil can be pulled into the sample bottle by a vacuum pump. Ideally the sample should be drawn from a point of about 50% level and as close to under the oil fed components as possible. Since gearbox sumps are designed to hold a large volume of oil, you would find the most concentrated contamination is on the bottom of the reservoir and the cleanest oil towards the top.

By just knowing the types of gear damage to look for, using a proper oil sampling process, and interpreting the physical properties of lubricating oil, a wind technician is able to identify common gearbox issues even before climbing down from the tower. Using these skills, they may even be able to save a turbine from continued damage that could result in total failure and extended downtime. A successful project should have documented sampling procedures that are followed uniformly by all team members. This ensures consistency in laboratory analysis and helps to structure the ongoing maintenance techniques of the project staff, especially for those who are new to the team.

Merritt Brown is vice president of Rev1 Renewables, an energy services company supporting wind, solar, and biomass clients worldwide. To learn more call (866) 738-1669 or go online to www.rev1renewables.com.

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Matthew A. Lackner, Ph.D.
UMASS Wind Energy Center

Tuned liquid column dampers offer a robust and cost effective means for reducing loads on floating wind turbines.

OFFSHORE FLOATING WIND TURBINES (OFWTs) may hold the key to large-scale offshore wind energy. They can operate in deep waters, far from shore where visual impacts are negated and where the wind resource is generally strong and consistent. However, OFWTs have significant challenges as well, in particular the increased loading on the blades and tower due to the higher inertial and gravitational forces caused by the motion of the floating platform.

In a previous column in this space, the work of Stewart (a PhD student at UMass Amherst) and Lackner was highlighted. In this work, passive structural control devices were investigated and optimized based on their ability to reduce fatigue loads in OFWTs. Structural control is traditionally a field of civil engineering that has been successfully employed for over 20 years in large buildings and bridges in order to reduce loading caused by wind and earthquakes, as well as to increase building inhabitant comfort by reducing acceleration of the structure. The structural control devices were evaluated using FAST-SC, a modification of the aero-elastic code FAST, which Lackner developed in order to model additional structural control degrees of freedom in offshore wind turbines. The optimal passive devices, determined using genetic algorithms, were shown to reduce fatigue and extreme loads in OFWTs by over 20% in some cases.

However, these previous investigations used an idealized passive structural control device, which is referred to as a tuned mass damper (TMD). The TMD utilized in the previous investigation consisted on a linear system with a mass, a spring, and a damper. Non-linearities in the equations of motion were ignored, except for position constraints to prevent the TMD displacement from exceeding the dimensions of the nacelle or platform. These idealized TMDs were useful for evaluating the potential of passive structural control. In the current research, Roderick (a M.S. student at UMass Amherst) and Lackner are evaluating realistic mechanical designs that can be used in practice to achieve the performance estimated by idealized simulations. In particular, it is critical to implement a passive structural control system that is both inexpensive and reliable, while still achieving good performance.

After evaluating a range of mechanical systems to be utilized as passive TMDs, tuned liquid column dampers (TLCDs) were selected as the best option due to their simplicity, low cost, and success in civil engineering applications. A TLCD is simply a U-shaped container of water, with two vertical columns connected by a horizontal column. An orifice is located in the horizontal column. Since water is the primary component of a TLCD, it can be quite cheap, and there are no moving parts. As a building vibrates, or in this case an OFWT, the water in the TLCD flows back in forth through the columns. As the water height in one column becomes higher than the other, a restoring gravitational force will bring the water level back to equilibrium. Because this force is proportional to the displacement of the water, it acts as the equivalent to the spring in an idealized TMD. Likewise, as water flows through the orifice, hydrodynamic losses provide a source of damping that is proportional to the square of the velocity of the fluid, thus making this a non-linear system. TLCDs with both constant area horizontal and vertical columns, as well as varying area are possible.

In their research, Roderick and Lackner have optimized the dimensions of TLCDs to minimize fatigue loads on a variety of offshore wind turbines, including a fixed-bottom monopole, floating barge, and floating spar buoy. Parameters that can be optimized include the horizontal length, the vertical water column height, the damping, and the ratio of the vertical column cross sectional area to that of the horizontal column. The horizontal and vertical column sizes must be constrained by the dimensions of either the nacelle or the platform where the TLCD would be located. A Monte Carlo optimization was used, and optimal dimensions were determined. One important constraint emerged, as the maximum water displacement must be less than the total length of the TLCD. As such, the damping values for optimal TLCDs tend to be larger than TMDs to restrict the water displacement.

In the optimizations conducted to date, the performance of optimized TLCDs shows promise. Fatigue load reductions are less than for idealized TMDs, but exceed 10% in some cases. Future work will also evaluate floating TLP and semi-submersible platforms. In sum, offshore floating wind turbines show promise for use in deep waters, but the increased loading from platform dynamics may lead to high structure costs. Utilizing optimized passive TMDs will reduce this loading, which will allow designers to use less material, and can lead to reduced overall system cost. TLCDs are a realistic mechanical system with low costs and no moving parts that can achieve significant load reductions in offshore floating wind turbines.

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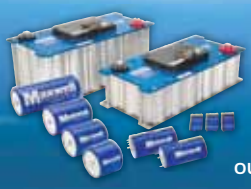

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Maxwell® TECHNOLOGIES
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Michael Graska
Professional Logistics Group, Inc.

In this installment we discuss the Seven Laws of Supply Chain Management that represent supply chain discipline and problem solving.

FROM ONE MY FAVORITE BOOKS, "A Road Less Traveled" by M. Scott Peck, the opening line is "Life is difficult". And as Dr. Peck states once we recognize this it starts to become less difficult. The difficulties are often represented as problems and it is how well we solve these problems that indicates the wellness of our lives. It is very much the same in supply chain management -- it is difficult, but once we recognize this, it becomes less difficult. All that is needed is some discipline in solving the problems. Presented below are my seven key Supply Chain laws, which represent supply chain discipline; discipline that leads to solving those difficult supply chain problems.

1. Law of Demand. It's really all about the demand– Why call it supply chain management? What is really demand management that gives direction to supply management? The issue is how independent and dependent demand affects a company's operations and hence it's supply chain. The more a company refines their knowledge and controls of demand management the more efficient and responsive the supply chain becomes.

2. Law of Paradox. Supply chain resources are not infinite. A company needs to balance the pull of being an efficient supply chain with customer responsiveness. Here is the paradox. Is your company supply chain model based on operational efficiency or customer service responsiveness? Which one do you choose in a business environment of finite resources? This choice drives your supply chain model.

3. Law of Metrics. As the old saying goes, what gets measured gets done. Does your company have the right mix of supply chain metrics? Do metrics communicate direction and change? These are questions that give your company direction, set expectations and measure improvement. Be aware of the number of metrics, too many and you can incur paralysis through analysis.

4. Law of People. Just because you bought that new $600 Titanium driver doesn't make you a Tiger Woods. People still have to make key supply chain decisions. Do you have the right people, making the right decisions at the right time? They need to be trained, nurtured and given the opportunity to succeed. People make the decisions that drive the company forward, not machines.

5. Law of Variability. Does it seem like you are on the tail end of the cracking whip?

Variability within a supply chain amplifies as a company's product and information move up the supply chain. Variability is the number one key to understanding when it comes to supply chain problems. Does your company have visibility and control to damper variability?

> "Variability within a supply chain amplifies as a company's product and information move up the supply chain."

6. Law of Optimization. Are you able to see the forest from the trees?

Most companies fall into sub-optimizing a few links within their supply chain without recognizing what that does to the entire chain. It is very tempting to tackle individual issues in isolation. But this often just creates other problems in other areas of the supply chain. The supply chain needs to be considered in its entirety when dealing with problems

7. Law of Contingency. Planning is great, execution is even better, but stuff happens.

Does your company have supply chain contingencies developed before they are needed? This is often the law that separates the good from the great. A great supply chain company anticipates problems and plans for it. Think of it as supply chain performance insurance.

Keep these laws in mind when dealing with your supply chain. Think of them as the blocking and tackling of supply chain. The laws will take discipline to understand and to implement, but get these correct for your company and your supply chain will certainly will be on track for excellence.

Michael Graska is project leader with Professional Logistics Group. For more information go online to www.prologisticsgroup.com.

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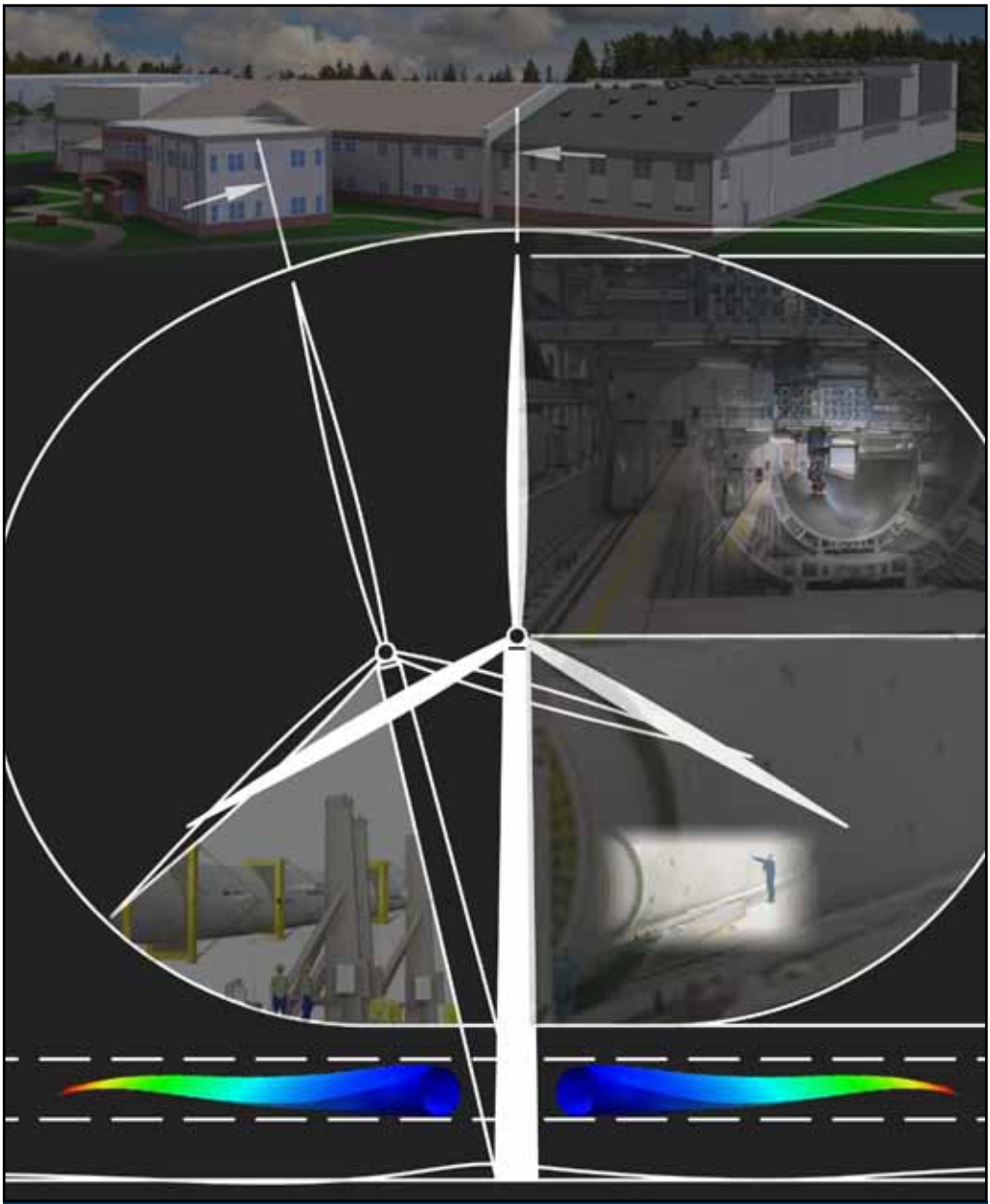
ADVANCED STRUCTURES AND COMPOSITE CENTER

By Sherri Mabry



Established by the National Science Foundation, the Advanced Structures and Composite Center is the only lab in the United States to include complete development capabilities for floating offshore wind turbines.

IN OPERATION SINCE 1996, the Advanced Structures and Composites Center at the University of Maine in Orono, is an 83,000 square foot lab employing 40 scientists and engineers and 100 graduate and undergraduate students. The center performs research and development in North America and around the world for the advanced study of materials and construction. "We are unique for our ability to design new materials, manufacture and test under one roof," says Dr. Habib Dagher, P.E., Director. "We can design a tower, make a tower and test a tower; design a plate, test a plate and make a plate."

The ISO 17025 accredited facility has 10 laboratories under one roof, housing labs for composite materials, manufacturing science, resin infusion, polymer/interface science, environmental-durability testing, mechanical testing, nondestructive evaluation (NDE), advanced microscopy, and large-scale multidegree-of-freedom static and dynamic structural testing. The center also houses two pilot plants: a Composites Extrusion Plot Plant and a Strand Composites Pilot Plant.

A new 37,000 square foot Offshore Wind Laboratory was recently constructed and enables the design, manufacture and testing of structural hybrid composite and nanocomposite components for deep-water offshore wind structures such as blades, towers, and spars.

FIXED OR FLOATING TURBINES

The Dynamic Marine Simulation Basin is one of only two facilities in the world with high quality wind and waves for scale model testing of fixed or floating offshore wind turbines with a tank measuring 32 feet by 100 feet by 12 feet. "We test blades measuring up to 230 feet and we are a certified lab accepted by agencies across the country and throughout the world," Dr. Dagher says. "We look at materials from nano-scale to full-scale. That is very unique." Dagher says the facility is also home to the largest structural testing facility that accommodates 230-foot long structures for testing with anchor forms. The facility is designed for use to apply loads in static and fatigue loading and blade testing at a million pounds of load.

The lab can also manufacture in vacuum infusion and perform filament winding or extrusion processes and compression molding of materials. In about a year a robot will be installed to automate the manufacturing process. "The robot in design now, travels on a track system and can produce complex 7-axis composite shapes up to 200 feet in length.

The robot will be used to construct bridge towers for wind turbines and blades by using interchangeable heads, performing all aspects of manufacturing from producing fibers and resin, curing, inspection and completion.

The ability to test blades measuring 230 feet is the largest facility available in the United States in an academic institution. "We are also unique in our environmental testing in that we have a large environmental chamber with activators that take a joint between a blade and the foundation of the structure and test under environmental factors such as relative humidity and temperatures from -50 degrees below zero to 150+ degrees to generate fatigue loading by bending and twisting the way the wind would do to a structure," he said. "We are able to conduct these tests under salt water to simulate offshore bending and twisting. I don't know of any facility that can do that under salt-water conditions. This allows us to determine failures of materials in nano and failure of design to improve systems."

FROM COUPON TO FULL-SCALE

Dagher says the center also works in atomic force microscopy and scanning electron microscopy to understand materials at a small scale. Testing from coupon level at six inches long, to a full-scale 230-foot-long structural level under static and fatigue loading and analyzing modeling and material structures are part of the expertise of this lab. "During our 16 years of existence, we have a long history of experience and a large staff tailored to the needs of our clients," he said. "One of the benefits of using our lab is that our partner companies don't have to build their own facilities. If they built a facility from scratch it would cost them $100 million. This is our specialty and we partner with companies to perform the work."

The center offers a preferred customer program where a client books time with the facility for two, three or four years, giving them priority in the labs. Many clients also appreciate the connections they build with graduate and undergraduate students and the university can become a feeder program where a company provides scholarships and in return hire the student at the end of their graduate studies in their own operations. "The student interaction with our clients and the scholarships and tuition assistance they receive is good experience for our students. In return, the companies connect with many high-caliber people for their operations."

In the past five years, the center has provided industrial collaboration on more than 300 product development and testing projects with small, start-up companies and large corporations.

Email hd@umit.maine.edu or call 207-581-2138 or visit www.aewc.umaine.edu.

BEST PRACTICE MACHINING OF WIND POWER COMPONENTS

Minor improvements in machining processes potentially result in major competitive advantages for the wind power industry.

By Brent Godfrey

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WITH WIND ENERGY STILL IN ITS INFANCY, currently realizing only a fraction of its potential, manufacturing parts for the industry is a pure growth proposition for many suppliers of machined components. There's nowhere to go but up, as windpower is heavily reliant on machined parts and is only gaining traction as a clean energy source. As the industry continues to grow, parts manufacturers have already taken notice of the opportunity, and even the most niche manufacturers are no longer the only game in town.

Competitiveness is good for the health of the industry, and suppliers have begun incorporating best practices to produce the best quality, lowest cost and most readily available parts.

Machining wind power components can be intensive, largely depending on the methods and means applied to the metal cutting process. For example: How long do shafts stay on the lathe? How up-to-date are the milling operations and cutters involved? With the sheer volume of holes being drilled, how efficient is the drilling? And how up-to-date is the gear milling process?

Taken as a whole, even otherwise minor improvements in each of these processes can represent a major competitive advantage. Improvements, for

Fig 1: High feed rate with soft cutting action is ideal for milling hubs and housings.

example, in tool material, aren't just a function of durability and reliability, but core to productivity. Advancements in productivity, combined with lengthened tool life, results in faster cycle times and less down time. This factors directly into the ultimate efficiency of a shop, and maximizes capacity and delivery capability.

For instance, developments in the area of insert coatings and substrate have a huge influence on performance. New PVD-grades feature a coating process that, when applied, lowers tensile stresses in the insert by countering with compressive stresses. The high-impact treatment process results in stronger and safer edge lines, sharper cutting edges, and can improve milling processes experiencing difficulty during entry or exit cuts. Also, low stress CVD coatings combined with post-coating treatments result in more wear-resistant inserts. The latest coating and insert technologies can be especially beneficial in high heat applications.

TURNING HEADS

Turning is such a tried and true staple of the metalworking industry that developments in this area are not as dramatic, especially considering the advancements in milling and the evolution of CNC programming techniques. But behind the scenes, progress has been steadily marching forward.

Turning wind power components involves a straightforward range of operations and demands. The dominant workpiece materials are various alloyed steels and cast iron, many in the form of castings and forgings. And the pieces are big – more than 20 tons. The main shaft, for instance, is a large, uneven forging, typically made of a strong steel alloy. Up to a third of the material is removed through machining, mostly through rough turning. The sheer size of the main shaft dictates long run times, and the operations include everything from heavy-duty rough to finish turning, and each has different demands on tooling. Optimizing this process can yield substantial gains in productivity.

Additional components, such as the slewing ring, can require even harder steel materials. Because both external and internal diameters are machined on vertical lathes, and because stability and fixturing characteristics change, tool choice tends to vary. Sandvik Coromant designed coated inserts that stand up to abrasiveness and high temperatures. This means a harder insert substrate with a coating that provides a good thermal barrier is usually most suitable. That combination aides resistance to plastic deformation and crater wear, and it helps to control natural flank wear while generating long tool life.

SUCCESSFUL HARD PART TURNING

Hard part turning also has earned a prominent place in hardened material component processes. Many applications that once relied on grinding now fall well within the scope of hard part turning; the old standby only used for certain niche applications. Innovations in machines, component material and hardening, set-ups, and the cutting tools themselves have made turning hard parts increasingly accessible to most machine shops. The transition from grinding to hard part turning presents a considerable suite of advantages gained by switching to a single-

Fig 2: Cutting edge precision is vital for making use of the latest developments in indexable insert technology in gear milling.

edge chip-forming operation.

Case in point, new machining technology has made hard part turning the go-to process for the case-hardened steel realm, especially for turning parts with a hardness range of 55 to 68 HRc. Several wind power components fall within this range – mainly shafts and gearbox wheels – so HPT is an important place to look to improve competitive advantages in wind equipment manufacturing. The process is very much about maximizing productivity, while staying true to a highly precise target spec.

Hardened materials require extremely hard cutting edges. That need is easily fulfilled by cubic boron nitrate (CBN) as the basic tool material. Some degree of edge toughness is also important because of the variance in mechanical loads arising from interrupted cuts or material inclusions. The relationship between the cutting edge geometry and the grade plays a pivotal role in optimizing performance and results. Finding the right combination of CBN grade and edge treatment is the key to successful hard turning operations.

ADAPTABLE BORING

The large diameter holes found on wind power components help to drive the development of a new generation of boring tools. As many wind power components continue to grow larger in size, features like the holes also grow, creating a requirement for new,

Fig 3: Hard part turning is now optimized through new combinations of CBN grades, cutting edge designs and an exact, stable insert location.

unique machining processes and tooling solutions.

Consider the machining of large diameter holes in a nodular cast-iron wind power component. Tool strength for roughing and tool stability for finishing are both paramount. These twin qualities are essential for achieving acceptable productivity, predictable tool life, and consistency within the required component tolerances and surface finish levels. The new generation of boring tools can achieve these qualities. Bearing housings, hubs, and gearbox housings are all components that can benefit from new large diameter boring tools.

The right insert grade for the operation and materials in wind power housings, be it a roughing or finishing application, is a vital factor in getting the most out of a boring tool. For finishing, inserts having relatively thin PVD coatings on a sharp edge may minimize deflection thus minimizing vibration tendencies. For roughing, a necessary combination is often toughness with a CVD coating that acts as a heat and abrasion-wear barrier. These attributes should be partnered with strong insert geometry to cope with unevenness, interruptions and chip jamming.

MILLING: THE WORKHORSE OPERATION

Milling some of the huge components that constitute wind power equipment requires adherence to best practices to ensure efficiency in throughput and to minimize production costs. The ability to remove material in the most efficient way available and perform various multi-axis operations is crucial to competitive production.

No other machining technique even approaches face milling and square shoulder milling in terms of the sheer volume of material removal. Good milling practices should lead to a satisfactory surface finish, and ultimately a maximum run time for the machine.

With most of the milling workpiece material being some grade of nodular cast iron, several degrees of milling cutter dedication is necessary for good performance, and recent tool developments have been up to the challenge. When face milling a short-chipping material like nodular iron, either a 45- or a 65-degree entering angle is generally regarded as the best option. These angles provide a good combination of feed-rate capability, cutting force balance for long tool-overhang, cutting edge strength and less workpiece frit-

Fig 4: An indexable insert drill that closely balances cutting forces results in holes with high diameter-consistency throughout a large range of cutting data.

tering that yields optimal results.

Square shoulder milling, edging, profiling and other end milling operations limit the entering angle of the cutter to 90 degrees, necessitating specific properties in the cutter. In the past, lots of square shoulder milling, including end milling, was performed with triangular inserts, as this was the only practical means by which to attain the required edge clearance. The introduction of square inserts presented a problem – improving tool performance was the primary objective, but there had to be four effective edges to provide better tool-cost efficiency.

For the square insert concept to work, it had to have sufficient cutting edge clearance, advanced geometry, and flexible edge lines to perform medium roughing through to the edge-precision for finishing shoulders and angles.

Round insert cutters also warrant consideration for roughing operations where the strongest of cutting edges makes a difference to performance and security.

DRILLING DOWN

When it comes to wind power components, making efficient holes is an especially competitive capability. The flange of the main shaft, the ring gear, the connecting ring, the gear-box housing, hub and main frame all demand holes, and lots of them. The majority of these holes are relatively shallow, with depths of up to five to seven times the diameter. These components are made of a variety of materials, and tolerances tend not to be as close as other operations require.

Because volume and speed are very important variables, productive hole drilling creates a ripple of positive effects on manufacturing costs and delivery times. These holes fall within the range of indexable insert drills, an area of cutting tool technology that has recently experienced considerable evolution. Today's short hole drill exhibits excellent penetration rates and finishing capabilities, while being operationally versatile and reliable. Even power requirements have been minimized.

The newest index-able drills have improved cutting action, chip formation and evacuation, machining rates, as well as tool life security and can also generate consistent hole quality.

The application area of indexable insert drills has been considerably broadened over the years, from drills for simple bolt holes to drills for holes designed for thread tapping. Each of these innovations has proven to arrive just in time to directly benefit the manufacture of several key wind power components.

GOING DEEP

When a holes depth is more than ten times the diameter, it requires specialized technology with standard single- or double-tube systems in place. Some holes may reach depths of 300 x D, and for some wind power components, it's necessary to machine features deep within those holes. This calls for specially designed tool-movement mechanisms, tool configurations, and cutting edges to make and finish chambers, grooves, screw threads, and cavities.

Drilling the center hole in the main shaft of a wind power unit requires support-pad technology for drill heads. New developments in this area of tooling, along with improvements in insert and head design, have led to innovations in deep hole drilling.

With the right tooling system in place, success is a matter of getting the small adjustments correct, and the devil is in the details. Using the best drill head with the recommended cutting data, a follow-up checklist should include: ensuring the best set-up, having acceptable chip evacuation, maintaining the required surface finish, achieving sufficiently long

tool-life, reaching the demanded tolerance consistency, and last-but-not-least, good hole-straightness. Furthermore, alignment between the drill head and the component is integral in avoiding any bell mouthing in the hole.

NEXT GEN GEAR MILLING

Wind power is dependent on high-precision gears as a first responder in the transformation from wind energy to electricity, and 90% of gear wheel manufacturing involves gear milling with a disc cutter or hob. A new generation of gear milling tooling moves past traditional high-speed steel to more recent cemented carbide inserts, for improved performance and productivity.

Gear milling's interrupted nature creates unique obstacles in the amount of entry and exit cuts, and in the high thermal variability seen by the cutting edge. This creates a unique demand combination of edge hardness and toughness.

New generations of steel milling insert grades adapted specifically to gear milling conditions provides a better balance of toughness and wear resistance. Sandvik Coromant's GC4240 insert grade, for instance, is a tough CVD-coated insert designed for steel milling applications where cutting edge strength is needed to cope with severe machining conditions.

The GC1030 insert, on the other hand, is a PVD-coated insert for applications where a more positive, sharper and tougher cutting-edge line is needed.

Next generation inserts are coupled with disc cutters and hobs engineered for optimal gear milling performance. Versatility is important when it comes to a gear milling product platform – full profile or conventional hobs and roughing or finishing disc cutters – must cover the range of roughing, semi-finishing and finishing applications.

STAYING COMPETITIVE

The advent of a wind powered age wouldn't be economically possible if manufacturers weren't able to cost-effectively create components with precision to close tolerances, and deliver them in a timely manner. That ability owes itself directly to the ongoing evolution of machine tools and tooling solutions. As wind power takes off, competition is increasing for better, faster and less expensive versions of the machined components. The only way to stay competitive is to keep pace with the onward march of progress in tooling, machining and manufacturing equipment and technology. Working with a tooling partner that has an understanding of wind power component production; has an extensive product offering; and the ability and desire to improve and continue to evolve, can make wind power component manufacturing a breeze.

INSIGHT HELPS WIND ASSET OWNERS MANAGE OPERATIONS

Software improves return on assets by identifying, predicting and resolving maintenance issues at an early state.

By Nigel Parlor

Nigel Parlor is business development manager for Romax Technologies. Romax Wind is a world leader in supporting wind energy, both onshore and offshore. It is part of UK-based Romax Technology. For more information, visit www.romaxtech.com or call 1-303-351-5418.

AT EWEA, COPENHAGEN, UK-based Romax Wind launched a new software and service platform named InSight, which it claims will improve return on wind assets by up to six per cent.

"Through close collaboration with operators, Romax was aware of the frustration in planning maintenance. There was a feeling that they were always reacting to failures," says Nigel Parlor, Business Development Manager at Romax Technology. "Not knowing when gearboxes might fail made business planning difficult."

Condition Monitoring Systems in the past have provided just a few months alert before a failure. Operators wanted more warning and InSight was created to tackle these operator challenges.

Developed over five years with more than 20 years of engineering know-how, InSight is designed to deliver a change in enabling wind asset owners to visualize the fleet condition and predict the remaining operating life of wind turbines down to subcomponent level.

"Romax's belief is that if you want a wind farm, or any other power generation asset, to achieve maximum output, you need to know both its current condition and what its future condition will be," Parlor said. "You also need to know the necessary changes

required in order to enhance future performance."

The ability to identify, predict and resolve maintenance issues at an early stage before they become significant is directly related to wind asset profitability and return on investment.

Cost savings in operations and maintenance have a significant impact on reducing the Cost of Energy (CoE), though industry data shows that improvements in Availability have a significantly larger impact. By focusing on improvements in availability, the resulting CoE reductions can be more than 10 times as effective in reducing CoE than on OPEX savings.

"InSight is bold – we are attempting to 'model out' the reasons for failure and create predictive maintenance (PdM) tools that are accurate, reliable and easy to use.

It is also important to ensure that maintenance is undertaken at the optimum time. InSight has been developed to meet these requirements."

InSight comprises three core elements. InSight Inspection and Analysis draws on experience in forensic engineering, studying machine behavior and field services to tackle maintenance issues. InSight iDS (Intelligent Diagnostic System is a powerful diagnostics platform, which provides precise visualization of fleet condition to asset managers and monitoring analysts.

InSight SCADA provides near real time visualization of fleet performance and interfaces with ERP systems such as SAP to enable optimised work scheduling and commercial control.

IDS is hardware independent, which means it can integrate data transmitted from multiple manufacturers' CMS equipment, presenting it in a single, unified and easy to understand dashboard. Our system display allows trends and potential problems to be identified far more quickly and easily than is possible via multiple system interfaces.

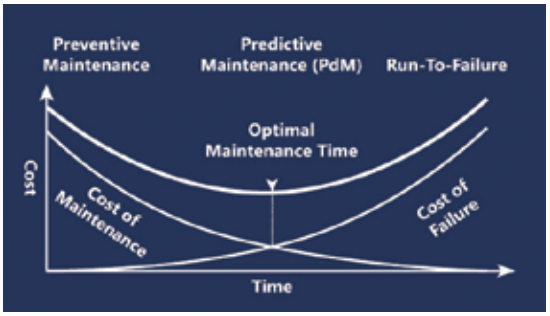
With more than two decades experience of modelling, analysing, and understanding machine behavior, and the vibration signatures of rotating machinery, Romax engineers incorporated advanced diagnostic rules into IDS, which identify tell-tale sign combinations long before they turn into serious machine faults. IDS is preloaded with diagnostic rules covering many major wind turbine manufacturers' machines and model type faults.

On-screen, InSight displays an 'alarm' for each turbine within a wind farm, as well as alarms for the gear, bearing, shaft and sensors of every drivetrain, with detailed diagnosis results of all alarms shown in a 'trend' graph.

CMS alone is limited in its ability to pinpoint the location of potential faults, with most only being able to indicate the sensor closest to the irregular vibration signature. Vibration analysis experts may also spend many hours identifying and

locating the most common faults using CMS data.

The InSight system is currently geared towards conventional planetary drivetrains, although software for direct-drive transmissions is under development.



Further development of InSight will incorporate condition monitoring of elements outside the drivetrain, with the next generation taking in componentry, including rotor blade pitch and yaw systems.

E.ON's 30-turbine Scroby Sands project is the UK's first offshore wind farm to have expired turbine warranties and be managed independently. This is an important early application of InSight.

"The InSight philosophy is based on experience and data collected over the past 20 years using some very clever algorithms and information," Parlor said. "We can give our clients a far greater insight into their assets and significantly increase their yield."

As turbines become larger and more sophisticated, operational costs and the impact on revenue resulting from bad decision-making will be significant. Offshore wind farms involve an enormous investment and maintenance is challenging. With 0.1 to 0.2 failures per year (1 failure per 5 to 10 years), the fact is the drivetrain failure rate is too high for offshore turbines, Parlor said.

With the offshore wind power market forecast to increase to 9.6 per cent of total installed capacity by 2015, InSight can make a serious contribution to operators.

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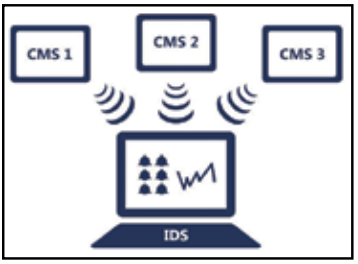

PRIMARY CAUSES OF TURBINE FAILURE

With the first large turbines (multi MW turbines) coming out of the warranty period, there are a number of reliability issues appearing. The main area of turbine downtime is the drivetrain, which includes the gearbox, generator and the main bearings.

There are three primary causes of failure. The first arises from maintenance issues. This is not always the fault of the operator; there are occasions when turbines do not lend themselves to component maintenance. An example is when a gearbox is well designed but the subsystem requiring maintenance is not. Similarly, if during assembly, parts were not aligned properly, future problems may arise.

Poor siting can be a further cause of turbine reliability issues, particularly where turbines are subjected to higher than necessary wind loads.

A third area is related to design flaws where a product line has problems that result in multiple failures downstream. Blade issues are not so common, but they present a significant expense when they do occur because the remedial work causes downtime.

Offshore operations requiring a blade swap can result in high costs.

Romax is developing products that will help schedule the flow of maintenance and quality assurance of maintenance procedures to allow operators to document and monitor both improvements and defects identified in the manufacturing process.

GIVING THE OPERATOR CONTROL

"The InSight solution comes from the technology side, rather than the service or product side" Parlor said. "This means that we are offering an independent view. This is an end-to-end solution, from a condition-monitoring hardware solution to a fleet monitoring service. We help clients put the processes in place and provide the training they need in order to operate their assets to optimum capacity. Our solutions give the owner control of everything rather than being tied to one service provider. Owner-operators can understand their assets and manage them on their own terms, so they are not tied into a hardware vendor."

A CRITICAL TIME

As the first generation of 1.5 to 2.5 MW class wind turbines enters maturity, there is increasing evidence of main bearing failures across a variety of turbine models, turbine manufacturers and bearing types. Failures have been experienced by operators in the US, Europe and Asia and in many cases a number of failure modes and symptoms have been found to be consistent across the fleets.

The nature of these machines is very different to smaller ones in terms of cost to operate, size and revenue generated. Technology levels are higher as are the value of assets. Correct management is more important than ever.

Romax also has a background in the design of drivetrains for multi-MW turbines, and experience in offshore wind farm product manufacturing that helps them solve customer problems.

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STAYING SAFE ON TURBINES

Fall protection training is crucial and necessary to insure worker safety.

By Jim Hutter

Jim Hutter is a senior training specialist with Capital Safety. For more information on fall protection training programs, contact Jim at jhutter@capitalsafety.com or call 1-800-328-6146 or visit www.capitalsafety.com.

EVERY DAY WORKERS RISK THEIR LIVES at extreme heights to accomplish tasks that are essential to the development and operation of wind turbines. With some of the tallest towers reaching several hundred feet, there is no margin for error. It is essential that all workers be protected from severe injuries in the event of a fall.

FALL PROTECTION STANDARDS

Every company performing work at height must have a fall protection plan in place in order to comply with the ANSI Z359.2 standard. A written fall protection plan is required whenever one or more person(s) are routinely exposed to fall hazards and need to be protected with a fall protection system. ANSI also requires a documented fall protection plan be developed by the program administrator, made specific for each site, kept up to date and stored at the worksite.

Clearly, a written fall protection plan is not enough to protect workers. Even the most comprehensive plan will fail if workers are not adequately trained to execute the program and use the equipment properly.

TRAINING: THE WAY TO A SAFER WORKPLACE

Formal training is crucial for any person who performs work at height. Without such training, work-

ers may not realize the severe consequences of a fall, including serious injury or death. Eager workers may be anxious to prove themselves and, if they see safety equipment as a hindrance, may forgo using it. Others could be embarrassed to ask about the proper way to use the fall protection equipment and may use it incorrectly, which will ultimately decrease the effectiveness, comfort level and usability of the equipment. It is therefore important to instill the value of fall protection training within your workforce.

All employers in the wind energy industry should provide training programs through every step of the process, including installation of the turbine and regular maintenance activities. Training courses are in-depth sessions covering a variety of pertinent topics, such as:

- Identifying, eliminating and controlling potential fall hazards
- Selecting the right fall protection equipment for the job
- Inspecting, using and maintaining fall protection equipment on a regular basis
- Executing the tactics within a fall protection plan
- Compliance with applicable industry standards

One of the most important areas of fall protection training in the wind energy industry is rescue. Since wind turbines are frequently located in isolated locations, more time is required for rescue crews to reach an accident scene. Another issue is that most falls occur near the top of the turbine, where rescue can be nearly impossible from the ground using conventional rescue tactics.

For both of these situations, employees will need to know how to perform a prompt rescue procedure. Prompt rescue is typically defined as within four to six minutes and no longer than 15 minutes following the fall. The difference between a non-injury fall and one resulting in serious injury has to do with how quickly a worker is rescued. The longer the fallen worker is suspended or trapped, the worse the injuries he or she may sustain.

WHO SHOULD PROVIDE TRAINING?

Many fall protection regulations specify the involvement of a competent person as defined by OSHA regulations 29 CFR 1926.32(f). OSHA defines a competent person as "one who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them." To become a competent person, one must undergo specific training and show adequate knowledge through extensive experience.

Competent persons should be identified within the company to oversee the fall protection plan, conduct fall protection training, and ensure all employees are prepared prior to working on a turbine. If you need help addressing fall protection topics or would like to ensure your training programs are comprehensive and in compliance, contact your fall protection manufacturing company. Many manufacturing companies, including Capital Safety, offer training courses for workers of all levels, and will work with you to develop a plan that is specific to the jobsite and appropriate for your workers' needs.

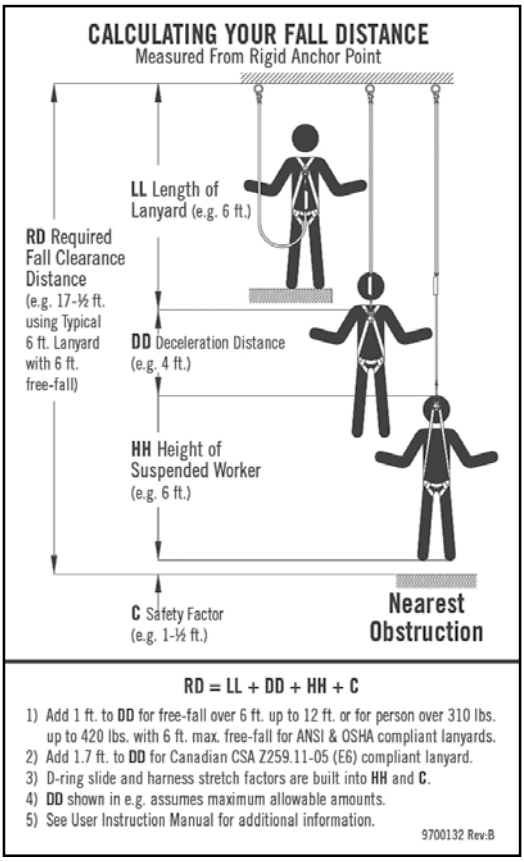
TYPES OF TRAINING

Since workers typically learn the most by watching and then by doing, it is best to conduct a training program with an equal amount of classroom and hands-on instruction. The key with any training program is to provide learning that approximates actual work conditions so the workers can easily apply what they've learned to real situations.

CLASSROOM TRAINING

An OSHA-defined competent person should conduct classroom training that is specific to the needs of the worksite in a controlled environment. The trainer must identify learning objectives and develop a lesson plan prior to conducting the class. Most classes combine lecture style training, including slides and video, with group discussions to apply theory to practical applications. Training manuals should be provided for workers to reference both during and following the course.

While many topics will be discussed during the course, such as those previously listed, it is crucial for trainees to review fall energy and fall clearance – the two most misunderstood topics. Many workers do not understand or even consider the amount of energy a fall generates. The force of a fall is dangerous and can extend the total fall distance considerably, leading to serious injury or death. For example, a 310-pound individual falling more than six inches will create forces up to 3,200 lbs. Understanding fall energy will help workers identify the best equipment to limit fall distance and thereby reduce the amount of energy generated in a fall event.



The other important topic to discuss in the classroom setting is calculating fall clearances. Should a fall occur, there must be sufficient clearance below the user to arrest the fall before the user strikes the ground or any other object. Fall clearance is more than a simple measurement from the worker to the nearest obstruction. The correct formula is the lanyard length + the energy absorber deceleration distance + the height of the dorsal D-ring on the harness from the worker's feet + the clearance to obstruction during fall arrest (see figure). Each of these measurements is critical and must be taken into consideration to correctly calculate the fall clearance distance. The results of a fall can be much worse, even fatal, if this measurement is miscalculated.

Equipment demonstrations and tutorial videos are also provided during classroom training to show workers best practices when working on the turbines. From here, workers should be prepared to move on to practical applications where they will experience firsthand how to properly use equipment and execute the fall protection plan.

HANDS-ON TRAINING

Hands-on training allows workers to learn by doing and gives them the opportunity to be corrected

"When talking about a harness, for example, there is no substitute for strapping into it, connecting to an anchor, experiencing how it feels and seeing firsthand what needs to be inspected before use."

- Jim Hutter

in a safe environment. When talking about a harness, for example, there is no substitute for strapping into it, connecting to an anchor, experiencing how it feels and seeing firsthand what needs to be inspected before use. Workers can also conduct mock trials of the fall and rescue procedures to become familiar and comfortable with the tactics in the comprehensive plan.

Hands-on learning experience can be offered either on or off the worksite. Courses at an offsite facility provide controlled environments uniquely designed to offer practical experience and unique complexities of working on a turbine. On-site courses, on the other hand, apply professional training to your specific daily work activities. By training in and around the workers' normal environment, you can ensure that the issues discussed are immediately applicable to your employees.

ASSESSMENTS

Training courses are typically competency-based, with each course having a specific and relevant unit of competency as indicated by the learning objectives and lesson plan. With these types of programs, writing assessments and/or hands-on exercises are to be completed by workers to show knowledge retention of the presented information and the ability to apply it in a work-like environment.

THE BOTTOM LINE

Wind turbine installation and maintenance calls for tight safety measures. With the sector showing enormous growth and potential for the future, the need for fall protection planning and training will be more important than ever. Give your workers the confidence they need to conduct their work safely with the right equipment and with the knowledge to help their co-workers in the event of a fall.

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PREPREG – LENGTHENING THE DESIGN ENVELOPE

New resin technology provides rapid curing and exothermic control to turbine blade spars and roots.

By Kevin Cadd

Kevin Cadd is the Technical Programe Manager, Gurit UK. For more information, call +44 (0) 1983 828 000 or visit www.gurit.com.

SUPPLYING MATERIALS TO THE WIND ENERGY market since 1995, Gurit specializes in the development of composite blade materials, meeting the demand for larger and more complex designs.

The tendency among large turbine manufacturers in the industry in recent years is to supply longer blades on existing turbine designs to suit light wind sites, or to install offshore turbines that are multi-megawatt machines, requiring larger blades, that can withstand higher loading.

The main load-bearing structure of a wind turbine blade is the spar component, which is either integrated into a structural shell as a spar cap, or constructed in parallel production to the shell as a separate spar structure complete with shear webs.

What is common to both approaches is that the utilization of unidirectional fiber (UD), glass or carbon, to provide bending strength and stiffness. The fiber also has to withstand compression loads; particularly in longer carbon blades and consequently the fibers need to remain straight and receive consistent support by the surrounding resin to prevent buckling. In order to enable longer blades to be designed it is important that the properties of the fiber are maximized when converted into a sparcap laminate.

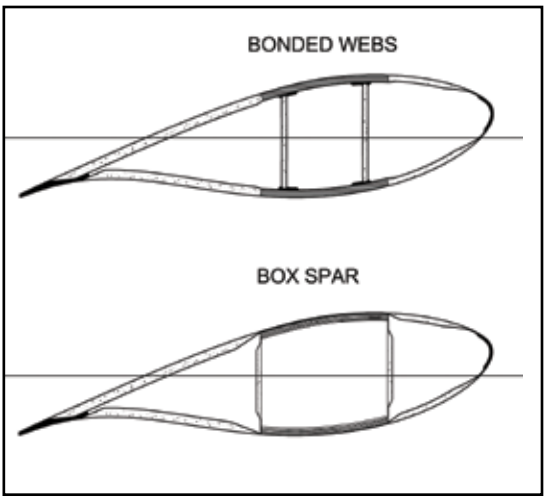


Figure 1: Structural Shell and Structural Box Spar Blade Designs

Collimated fiber formats like prepreg provide a good starting point to achieve these requirements, but there are additional challenges to maintain the fiber straightness and prevent voiding during the application and cure of thick section spar components. Other factors outside of material performance also play an important role in material and manufacture process selection, such as storage and lay-up temperature and tooling specification.

Gurit has set out a clear strategy to address these barriers to allow the use of prepreg in order to maximize the performance of unidirectional fiber and enable the next generation of blades. Two key technology steps in this strategy are:

– Velinox™ Resin Technology – to enable low cost tooling, eliminate cold storage and minimize cure time
– Airstream™ Coating Technology – to enable very low void content laminates without debulking or the requirement for air-conditioned factories.

VELINOX™ RESIN TECHNOLOGY

Velinox™ is a new resin technology, developed by Gurit as a next generation resin platform to enhance Gurit's current wind energy Prepreg and SparPreg™ products. The resin has been designed specifically for the cure of thick sections, such as wind turbine blade spars and roots. This chemistry does not exotherm in the same way as a standard epoxy, enabling the cure profile to be modified to eliminate time-consuming dwell periods that control exotherms in conventional resin systems. The result is a greatly reduced production cycle improving the mould utilization with the additional benefit of lower wear on moulds due to the lower peak temperature. The system can be cured at temperatures as low as 100°C, but can also be used for rapid manufacturing of components through its 10 min cure at 130°C and 20 min at 120°C even at thicknesses up to 100mm. Therefore, both thick and thin laminates can be cured quickly and provides the option to specify low or high temperature performance tooling. Figure 2 shows the temperature profile of the centre of two 92mm glass laminates. In the laminate with the conventional epoxy system (red line) a 70°C dwell was used to minimise the peak exotherm. The Velinox™ system (blue line) does not require a dwell and therefore can be heated directly to the preferred cure temperature (blue dotted line), which in this example is 125°C. A small exotherm is observed

with a delta of only 15°C and full cure is achieved in approximately 10 minutes from the peak temperature time.

While the primary advantage of the new resin system is rapid curing and exotherm control, Velinox™ also addresses another disadvantage of conventional prepreg materials – cold storage. Most epoxy prepreg systems have latent curing technology, which enables pre-mixing of the resin and hardener before fiber impregnation. The prepreg then remains in an uncured state until reaching higher temperatures (>70°C) to activate the catalysts. However, in practice, the prepreg will slowly cure at room temperature (from days to weeks depending on the system) and therefore for purposes of shipping and stock control the prepreg needs to be chilled or frozen. The new resin technology has different catalyst technology from conventional epoxy prepregs and therefore has significantly improved shelf life characteristics. With a shelf life of over 4 months at 35°C the need for a frozen or chilled supply chain is eliminated reducing both freight and storage costs.

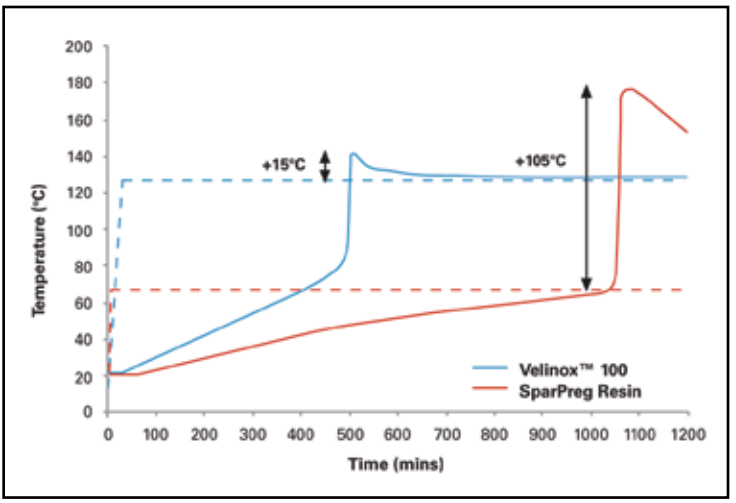


Figure 2: Despite curing Velinox 125°C, only a 15° C exotherm above the air temperature (dashed lines) is observed compared to 105°C using a standard resin.

AIRSTREAM COATING TECHNOLOGY

Velinox™ resin technology addresses two of the common problems of using prepreg materials, of exotherm and material storage. However, this

alone does not enable the manufacturing of high quality wrinkle free parts with low void content, which is critical to prevent premature failure of the laminate and maximize fiber structural contribution. The optimal utilization of the fiber properties is particularly relevant when considering the high cost of carbon fiber.

Conventional prepregs are processed using vacuum bag technology to remove the air between the plies prior to consolidation and cure. However, as laminate thickness increases it is difficult to maintain high quality, low void content laminates without the use of multiple debulking steps and/or the use of high-pressure autoclaves to consolidate the plies. However, due to the size of spar caps and the manufacturing cost targets it is not feasible to use multiple process steps or expensive capital equipment. It is for this reason that specialised prepreg products have been developed to enable the manufacture of high quality large structures for the wind energy market.

Figure 3: A Wrinkle in a carbon laminate after consolidation

While it is important to maintain voiding within the laminates to a low level (<3%) and to ensure individual voids are small in size (< 1-2mm diameter) what is more critical is to avoid the introduction of wrinkles in the laminate. A wrinkle of even small amplitude can

produce an area of laminate that would be more susceptible to buckling under compression loading. The avoidance of wrinkles is a significant challenge in spar cap manufacture due to the geometry and thickness of the component. The tooling often has a double curvature profile, which requires the prepreg material to have significant drape capability and wrinkling resistance. This can prove a challenge for a number of reasons: the prepreg is typically only 500-600 microns thick and therefore is generally susceptible to buckling if not handled carefully; the drape increases with temperature, but the removal of inter-ply air decreases rapidly with temperature reducing the process window for good drape characteristics; and the draping of a prepreg is a time dependent viscoelastic process, which complicates rapid deposition using automated application techniques.

One approach to increase the process window of spar manufacture is the use of a lightweight scrim laid in between each ply of prepreg. This increases the airflow between the plies under vacuum pressure enabling the removal of air between the plies and therefore reducing residual void content. However, this approach has some drawbacks as the scrim can decrease the compression strength of the laminate and the beneficial air removal effect is still limited to temperatures around 25°C at which point the tack of the prepreg becomes problematic. As a typical blade manufacturing plant can run at temperatures as high as 35-40°C in the summer months this solution has its limitations due to the high operating costs of air conditioning.

To overcome the conflicting material characteristics of low tack at the same time as high drape, and avoid any detriment to mechanical performance, the new product using a specialized coating technology to give the combination of:

- An air venting structure on the prepreg surface(s) that operates under vacuum even at temperatures as high as 40°C;
- A controlled level of tack and handling properties over a wide temperature range (15-40°C);
- And mechanical performance consistent with uncoated prepregs

The increased air permeability between the plies provided by the coating is an extremely effective way of removing inter-ply porosity when the vacuum is applied. The resulting laminate has very low void contents (<2%) even when factory temperatures are in excess of 35°C.

The second feature of the product is the low tack and high

drape it exhibits over a wide temperature range. The coated surface of the prepreg promotes sliding of the prepreg plies during layup and subsequent vacuum consolidation, preventing "stick-slip" and the formation of wrinkles.

Conventional prepreg processed at temperatures around 25°C would produce laminates with void contents in the order of 10-20% even without considering the formation of large wrinkles.

As the design of large multi-megawatt wind turbines progress, more designers are investigating the benefits that prepregs bring in terms of mechanical performance and quality assurance. As many of the designers are more familiar with infusion technology they have some reticence about the manufacturing complexities and overall cost of using prepreg. With Velinox™ Resin Technology and Airstream™ Coating Technology, Gurit hopes that its new prepreg developments will address many of the concerns surrounding the adoption of these materials and significantly reduce the cost of use by taking a holistic approach to material development.

Figure 4: A laminate manufactured using Airstream™ Coating Technology at +38°C. Void content <1.5%.

AUTOMATING WIND BLADE DEVELOPMENT FROM ROOT TO TIP

By adopting and executing a product development process that integrates design with performance simulation to find problems before they occur, engineers can avoid blade failure in their designs.

By Olivier Guillermin and S. Ravi Shankar

Olivier Guillermin, Ph.D., is Director of Product and Market Strategy, and S. Ravi Shankar, Ph.D., is Director of Simulation Marketing, Siemens PLM Software. For more information, call 781-250-6800 or visit www.vistagy.com.

IT'S A DAUNTING ENDEAVOR FOR A COMPANY to competitively and successfully develop longer, lighter and higher quality wind turbines in today's economic and political climate with so many technical and financial risks at stake.

In this context, turning to automation for the design and manufacture of wind blades holds the promise of many advantages, including faster time-to-market, reduced engineering and production costs, enhanced quality and performance, and improved design tailoring capability.

In fact, the larger wind turbines become, the more critical it is to adopt automation. Labor-intensive processes don't make sense economically in the long run. And with the wind industry developing increasingly complex blades that may soon reach 100 meters (or 328 feet) in length, a high degree of manufacturing automation is essential to ensuring the long term viability of this industry.

But proper adoption of automation requires a reassessment of the whole development process. Using automated manufacturing systems alone doesn't guarantee that wind turbine-manufacturing firms will profitably meet the expanding demand for high quality blades. Indeed, without a way to rapidly optimize the designs for automated processes, accurate-

Pictured above is a Nordex wind turbine blade being readied for full scale testing. Fibersim composites engineering software enables Nordex to rapidly define the composite blade layups in great detail as well as in its as-manufactured state. Fibersim allows wind blade manufacturers to achieve better margins of safety, lighter weight and a reduction in the number of prototypes required to get the blade into production.

ly assess the producibility of wind blades and fully integrate the design, validation and manufacturing process, automated production systems represent an incomplete solution to a complex challenge.

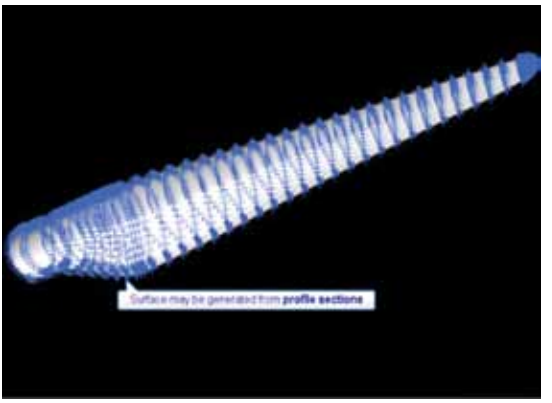


Figure 1: Shown is the 3D CAD model of a wind turbine blade in the Siemens PLM NX CAD environment. The blade surface is typically constructed from predefined sections, such as NACA profiles for aerodynamics.

ENHANCING THE POWER OF ANALYSIS

Composite wind blade designs offer huge advantages in terms of weight savings and durability. However, they also bring on unique challenges for the engineering analyst who has to ensure risk-free performance while dealing with complex shapes, thousands of plies, and properties that change along the entire length of the blade.

Because of this inherent complexity, composite design and analysis for wind turbine blades is a highly collaborative and iterative process. The process typically begins with early system level models that feed a computation fluid dynamics (CFD) analysis. Cross sections at various stages are derived and sent to the CAD and CAE teams. Sophisticated CAD applications are then used to generate the 3D model of the wind blade. For instance, NX® software from Siemens PLM Software can be interfaced directly with the system engineering solutions to read in scan lines or point cloud data and create a high quality surface through lofting and freeform modeling.

The early CFD analysis also provides the pressure loads that need to be mapped onto the blade for CAE analysis. So while the CAD team is busy generating the 3D model, the analysis teams can be working on preliminary sizing and optimization. Many CAE engineers use 1-D equivalent beam models for initial optimization and then build 2D models to represent the detailed structure.

The CAE applications for analyzing laminate composites derive the properties of the ply material based on defined properties for the fiber and matrix materials. They also support a range of theories that seek to predict ply strains and stresses and the onset of delamination or core failure. Typical simulations include evaluating stresses at the blade

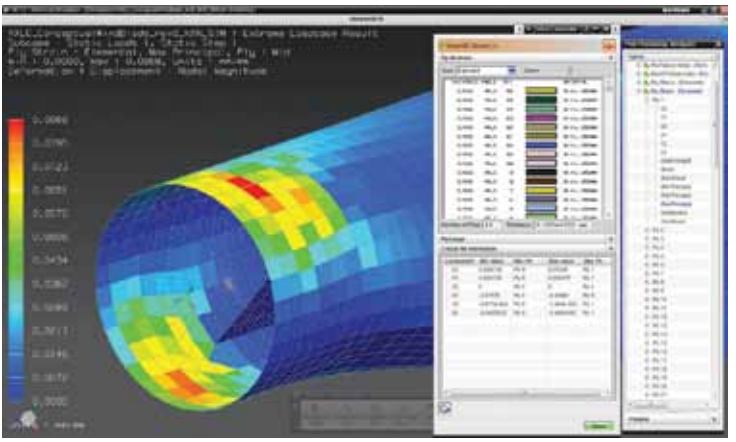


Figure 2: Fibersim and Laminate Composite are fully integrated with Siemens NX, enabling a parallel design and analysis workflow with data exchange of ply shapes and true fiber orientations for shell and solid finite element models.

root and around bolted joints where the blade connects to the hub, vibration and modal analysis, and nonlinear buckling analysis of the skin. Additionally, engineers evaluate the blade for maximum tip deflection and fatigue loads. Since the blades are subjected to a wide range of load cases (wind direction, gusts, etc.), it is also useful to evaluate load case envelopes to identify overall margins of safety.

The objective is to find an initial solution for where and how much material should be deposited and how it should be oriented in order to satisfy a range of performance criteria. The material and layup definitions also have a major effect on whether a part can be produced, hence the need for easy sharing of models and data between geometry design tools, CAE applications and specialized applications for composite design.

NX is a good example of an environment that supports the rapid iterations that are needed for composite blade design. Data generated in the NX CAD application is seamlessly made available within the NX CAE application, which includes a dedicated solution for the analysis of composites. Associativity is maintained throughout so that any change in design can be cascaded easily to update simulation results. Finally, the initial layup information generated in NX CAE can be shared bi-directionally with Fibersim™

composites engineering software from Siemens PLM Software.

STAYING TRUE TO THE DESIGN

All too often what is being made in the factory is different from what was designed, analyzed and documented in the design office. Issues arise on the shop floor that were not expected and inevitably leads to design changes.

Software that provides the ability to perform a producibility simulation, such as Fibersim, enables an organization to verify early on in the development process that manufacturing will be able to make the parts as designed. For manufacturing organizations to be successful, designers and stress engineers must have access to producibility simulation data prior to the time their colleagues on the shop floor start manufacturing blades.

Indeed, in order to produce a wind blade to specifications with fewer risks and less waste, one should accurately simulate the manufacturing process and learn of potential problems during the time that early design and optimization are being conducted.

This is especially true for today's football field-length blades because they are comprised of thousands of composite plies and core panels. Multiple materials, including glass and carbon fiber fabrics, various resins and bonding pastes, balsa and foam core may be used in a single blade. The ability to stack and stagger plies in different sequences and orient material fibers along specific directions en-

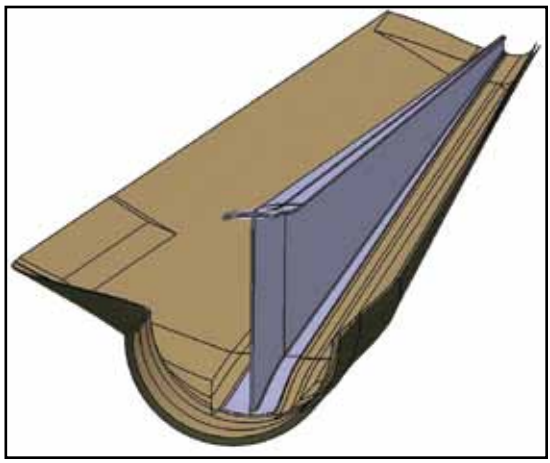


Figure 3: In order to ensure that glue gaps are minimized and the wind blade assembly meets performance and quality requirements, it is critical to be able to build a solid model of each composite component. The Fibersim offset surface capability allows the composite designer to devise an offset surface for a designed laminate. The offset surface shape depends on the number of plies and core pieces, and their shapes and thicknesses.

ables the building of stronger and lighter blades, but it also greatly increases the amount of design and manufacturing data to deal with. Given the complexity of working with so many different materials, it is imperative to accurately simulate how they will fit together once it all hits the manufacturing floor.

By combining accurate simulation of various processes and materials and reducing the complexity for designers and structural engineers, such software solutions ensure that the components of a wind blade—skins, spar caps, web, box beam, and root laminate—will indeed be producible when manufacturing starts.

Such producibility simulation enables the timely discovery of potential problems, including fabric folding, wrinkling or bridging issues. These issues may result from excessive steering, pulling or pushing of the fabric while laying down plies or courses in the blade mold. Ultimately, it can trigger preliminary breakdown of the blade by progressive delamination, de-bonding and crack propagation, leading to catastrophic failure.

If detected early by the producibility simulation, these issues can be resolved quickly by changing the ply design in various ways, including ply darting, splicing, re-draping, or material and orientation changes. This can all be done directly on the computer using Fibersim's simulation capabilities, which drastically reduces the need for costly physical testing and shop floor rework.

What's more, materials suppliers and transformers are constantly innovating with new types of fabric weaves or stack-ups which results in new forms of composite materials, some of which are tailored to large composite structures. Among them, Non Crimp Fabric (NCF) and multi-axial fabrics are now extensively used in the wind industry. Such materials present some new and very specific deformation behaviors when draped on the tool. For example, they are more prone to micro-buckling deformations. These deformation modes must be accounted for by the producibility simulation software in order to generate useful information for blades made with these new materials.

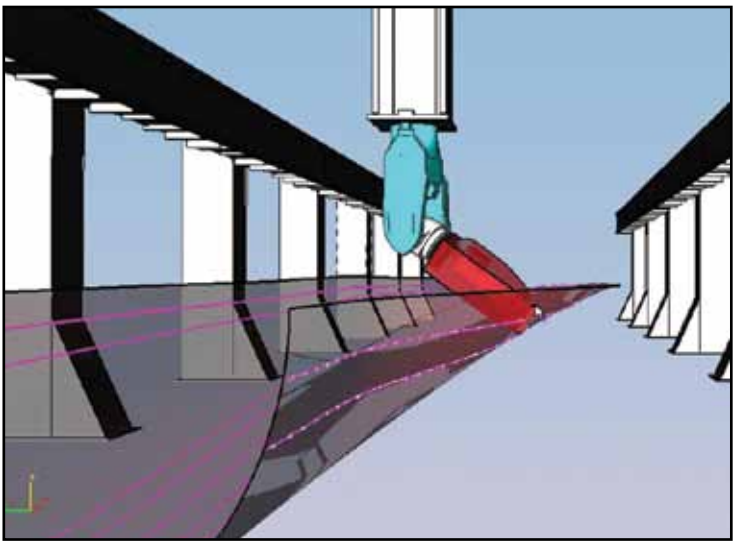


Figure 4: In order to ensure, define and verify the instructions for automated manufacturing, computer aided manufacturing software is used to simulate the manufacturing process and generate the codes for the machine head. Shown is a collision between the head of the machine and the tool surface. Components in red are colliding, hence the trajectory must be adjusted to ensure a smooth deposition.

The benefits of producibility simulation have been proven in production across multiple industries by companies such as Bombardier Aerospace, BAE systems, Nordex, Sinomatech and others.

With the advent of automated deposition systems for wind blade layup operations, a complete and accurate producibility simulation capability is even more critical. That's because in traditional manufacturing, the engineers and technicians who are confronted with manual layup issues on the shop floor will often have enough experience and knowledge to devise a workaround "on the fly" to get them over the hurdle. While this is less than ideal because it is not repeatable and increases the risks of an imperfect blade, at least it keeps the manufacturing process moving forward.

With automated deposition systems, the machine is unable to figure out manual workarounds "on the fly." Events and alternatives are either pre-programmed or they are not. When the answer to an issue is not available, the machine stops, or may damage the part or the mold. Precious time is wasted halting the automated deposition process for lengthy manual interventions. Such downtimes are major productivity killers and the reason why some companies have delayed adopting automation.

In order to control the risks of new technology, such as automated deposition systems for wind blades, it is imperative to root the engineering process in a complete, accurate and reliable producibility simulation of the manufacturing process.

AVOIDING FAILURE

As described in the previous sections, the laminate sizing and layup information along with the

detailed surface representations are inputs for detailed laminate design and subsequent producibility simulations.

However, the material orientations derived from the draping simulations can vary enough from the initial definitions that an accurate final validation step is necessary. The detailed design will also have numerous ply drops and thickness variations that typically would not have been part of the initial sizing and optimization step.

In the validation stage, high fidelity break-out models that use layered solid elements can be built. When physical test data is available, finite element models can be refined to correlate with the test results. These correlated models can then serve as a basis for detailed analysis and conducting tests in a variety of operating conditions up to the point of failure, which is prohibitive to perform on a physical part.

INCORPORATING DESIGN & MANUFACTURING

So clearly, making sure that the part is optimized, verified, and fully producible is paramount before manufacturing starts. But there is another critical ingredient that is required to deliver an efficient and reliable blade manufacturing process: The adoption of an integrated design and manufacturing process.

Manufacturing teams making blades in the factory often encounter problems that stem from the fact that while some data may be available in the design office, either digitally or on paper or in the heads of the designers, some of that data has not made it to the shop floor. Or if it does make it, it is incomplete or not accurate enough for the manufacturing engineers to fully and precisely reproduce the design intent. They are left trying to figure out some of the details and fixing some of the apparent contradictions.

Furthermore, late modifications and design changes performed in the shop—sometimes major ones—are not communicated back to the design and analysis teams due to time pressure and other higher priority tasks.

An integrated design and manufacturing approach will remedy this type of situation.

Integrated design and manufacturing is a cornerstone of composites manufacturing. It is critical to reaping the expected benefits of automated deposition applied to wind blades.

For the automated manufacturing process of a blade to be reliable and lead to the expected time and cost savings, a complete, detailed

and producible definition of the part must be communicated seamlessly from the 3D composite model to the digital manufacturing environment and, ultimately, to the machines. The goal is for the machines to produce the part exactly as designed.

A seamless link from the 3D composite model to the automated deposition system conveys consistent, complete and reliable data that reflects engineering intent, detailed ply and core layup definition, manufacturing constraints and exceptions handling.

Such a seamless link is illustrated by the connection between NX, Fibersim and the Tecnomatix® software for manufacturing simulation and planning, which allows the automated transfer of a producible wind blade design to digital manufacturing. By providing complete data about how the fabric should be laid down to avoid manufacturing problems, this link enables the fabrication of a wind blade by machine systems that can layup rolls of materials with significant time-savings compared to manual processes.

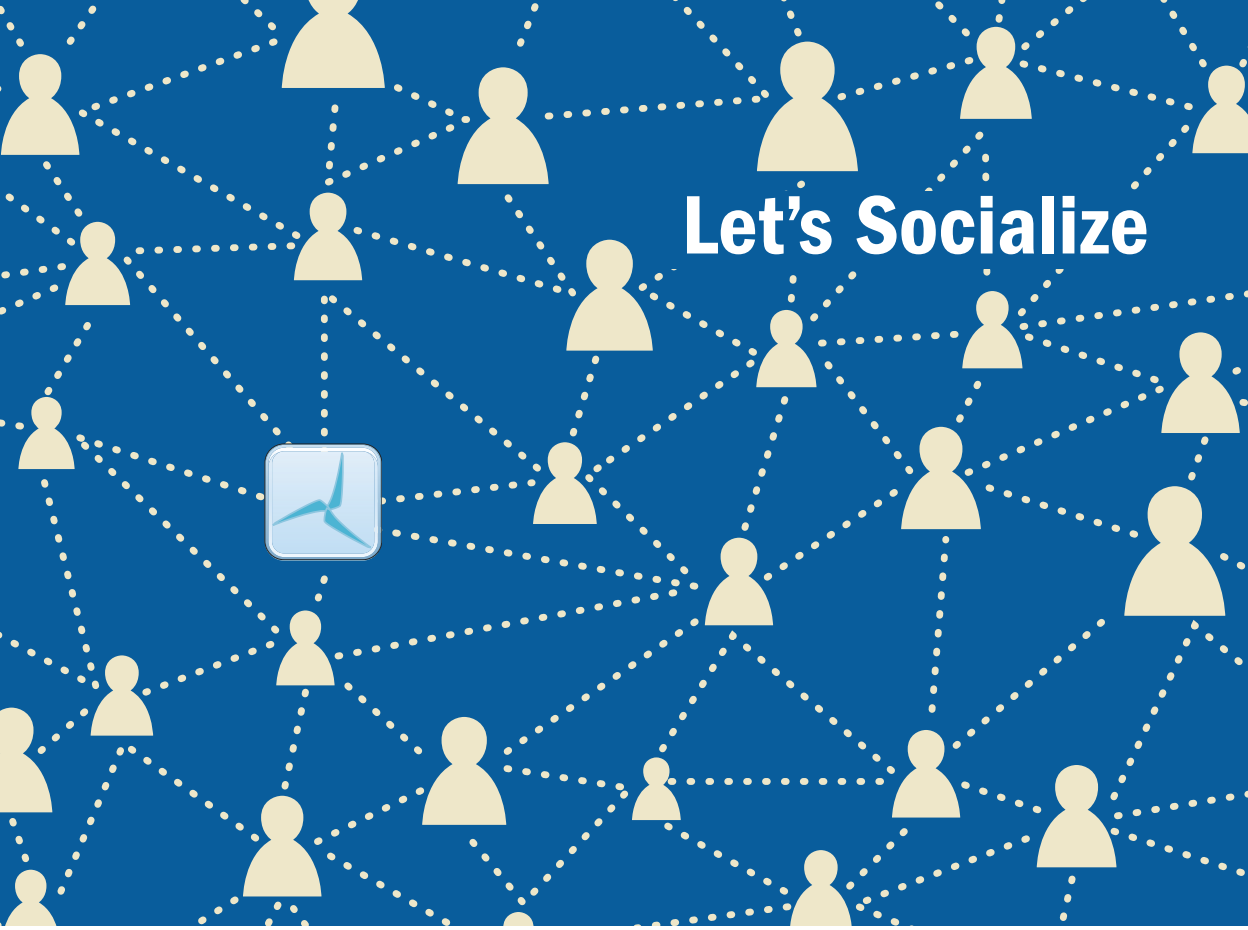
STAYING TRUE TO THE PLAN

The wind industry is following in the footsteps of aerospace firms by moving to automated deposition of composite materials for large composite parts. While automating wind blade manufacturing can save time and reduce costs, there are significant risks if the machine system is not fed with the appropriate instructions from a producible part definition.

Within the Siemens PLM Software portfolio, composite design software, such as Fibersim, provides the ability to simulate the fabric deposition completely and accurately to ensure producibility of the design.

In addition, by combining Fibersim with the capabilities of NX CAE software for analysis and Tecnomatix Process Simulate integration, the organization can guarantee seamless communication of the detailed and validated design to the shop floor. This digital process ensures that the parts are manufactured as designed and analyzed.

Without such a blueprint, the costs could be high. Imagine a 70-meter long blade attached to a wind turbine that weighs more than several hundred tons and is raised almost 500 feet off the ground. Now imagine a failure in the blade structure. With structures as large as these, blade failure can cause catastrophic damage to lives or property. Failures can also lead to long shutdowns for costly repairs. What can engineers do to avoid blade failure? The answer is to adopt a well-executed product development process that integrates design with performance simulation and producibility simulation to catch all the problems before they arise.



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ARE WE REALLY BUILDING THE BEST WIND TURBINES?

A new turbine design uses old-fashioned know-how to reduce total capital costs, generate more power, and lower maintenance costs. Is this the future of wind turbine technology?

By Glen Lux and Marko Yanishevsky

Glen Lux BSc. Eng., is CEO of Lux Wind Power Ltd., Saskatoon, SK, Canada. Marko Yanishevsky, MASc PEng is with the Structures and Materials Performance Laboratory, Institute for Aerospace Research National Research Council Canada, in Ottawa, ON, Canada. For more information visit www.luxwindpower.com or call 306-221-3297.

EVER SINCE THE WRIGHT BROTHERS USED cables to strengthen the wings on their early planes, this approach has been perceived as outdated, or simply put, old fashioned. However, the Glen Lux designed, built, and patent pending Vertical Axis Wind Turbine (VAWT) is unique in that it uses this highly effective technology to reinforce its multiple blades. For example, the Lux VAWT design with a one-megawatt power generating capacity has one-third the total weight of a comparable Horizontal Axis Wind Turbine (HAWT), mainly because it does not rely upon a tower or central column. The Lux VAWT also uses the same blade profile along the entire blade length, thus the reduced construction inputs drastically reduce the capital costs.

The Lux VAWT has six evenly spaced blades that are curved into an elliptical shape. The chord length of the blades is shorter than previously used blades, but the structural part of the rotor is reinforced by the use of several small diameter cables. By strategically attaching the cables to the blades, the aerodynamic drag is minimized. The cables follow a near circular path between their blade-to-blade connections. This results in a small amount of lost power; however, the structural integrity of the rotor, which consists only of blades and cables, is significantly enhanced. There is no need for an expensive central column or struts.

Previous Vertical Axis Turbines vs Lux Vertical Axis Turbine		
Feature	Previous	Lux Turbine
Vibration Problems	Yes	No
Torque Ripple Problems	Yes	No
Central Column	Yes	No
Struts	Yes	No
Guy cable tension	High	Low
Cross Cables	No	Yes
Life expectancy	Short	Long (beyond 20 years)

From the 1970s to the 1990s researchers from Sandia Labs in Albuquerque New Mexico, and the National Research Council in Ottawa, Canada worked on VAWT or Darrieus-style turbines, with two or three blades rotating around a vertical axis. The more common type of wind turbine is the HAWT that rotates around a horizontal axis. At that time it was unclear which style was more economically feasible. Both types had their limitations.

As these two organizations experimented with two and three bladed turbines, they tried different blade profiles, adjusting solidity ratios, height/diameter ratios, and blade curvature, offset blade angles and strut positioning. The power outputs were comparable to the HAWT, however, several of these demonstrator prototypes, including the largest VAWT ever built, a four-megawatt turbine in Quebec, encountered structural problems. A five hundred kilowatt turbine located in Prince Edward Island had a premature structural failure, primarily due to fatigue and corrosion issues. In addition, these two bladed designs suffered from large fluctuating torque excursions that caused poor power quality.

For the past few years Canada's National Research Council analyzed a Lux Turbine model with a diameter of 40-meters and a height of 65 meters with a one-megawatt power output. The Aerodynamic Lab used the Double Multiple Stream Tube Model computer program to predict the power output and wind loads along the entire length of each blade as the VAWT was rotated. These aerodynamic lift and drag loads, along with the centrifugal and gravitational forces were then applied to the six blades of a Finite Element Model of the Lux VAWT by the Structural and Material Performance Lab. The computer simulation program was used to determine the locations with the most damaging stresses and deformations. From the operating range of rotational stress data and using rainflow analysis they were able to predict the levels of damage to the blades, caused by these forces. The analysis performed by NRC, was for an International Electrotechnical Committee class II wind regime. Using a simulated annual wind spectrum, NRC predicted a life expectancy for the modeled blades to be measured in centuries instead of years. Deformations, even at extreme wind speeds that would be encountered once in 50 years, were exceptionally small. Further analysis on blade natural frequencies, temperature gradients, extreme wind loads and buckling were also achieved without any concerns to their long-term performance. The multiple blade design eliminated the torque excursions, a major source of structural fatigue loading, and achieved minimal torque ripple resulting in improved power quality.

The NRC also scaled the turbine to a remarkable 160-meter diameter with an approximate output of 16 MW. Surprisingly, the blade stresses remained relatively constant. It appears the maximum turbine size is only restricted to the economies of scale. As an added plus, large VAWTs are able to take advantage of the higher winds

Horizontal Axis Turbines vs Lux Vertical Axis Wind Turbine (2MW and larger)		
Feature	Horizontal	Lux
Overall Cost	X	0.5X
Overall Weight	X	0.3X
Total Blade Weight	X	1.2X
Total Blade Cost	X	0.6X (See note 1)
Rated Power	X	X
Annual Power Production	X	X
Swept Area	X	1.07X
Rotational Speed	X	0.7X
Hub/Equator Height (>2MW)	X	X
Peak Efficiency - Cp	High	Moderate
Mechanical	Gearbox or Direct Drive	Friction Drive (See note 2)
Main Shaft & Bearings	Large	Small
Tower	Yes	No
Pitch System	Yes	No
Yaw System	Yes	No
Hydraulic System	Yes	No
Moving parts within the Rotor	Yes	No
Concrete Volume for Foundation/Anchors	Large	Small
Size of Assembly Crane	Large	Small
Transportation Costs	Moderate	Small
Assemble Costs	Small	Moderate
Accessibility for Maintenance	Difficult	Easy
Costs for Offshore Installation	High	Low
Amount of Land Required/Turbine	Small	Large
Watts/sq.m. of Wind Farm	2 to 3	30 (See note 3)
Money Spent on Previous Research	Large	Small
Possibility for Technical Improvements	Small	Large

The Institute of Aerospace Research (IAR) in Ottawa, Canada, used computer models to analyze the aerodynamic and structural properties of the Lux turbine. The following information is a combination of the IAR report and from observations and data collected from several prototypes.

Notes

1 - Includes Splices and Cross Cables.

2 - The Friction Drive consists of a large diameter driving wheel and several small diameter driven wheels. This friction drive system is similar to the system used on railroads to transfer 6000HP from the locomotive wheels to the rails on a railroad system.

3 - VAWT's May Be Solution to Power Density Challenges - a study of modern wind farms comprised of (HAWTs) and counter-rotating (VAWTs) by John O. Dabiri, Ph.D, published in the *Journal of Renewable and Sustainable Energy*, July 19, 2011.

above the earth's surface without the use of towers, making them ideal for use off shore.

VAWTs built in the past have certainly had their problems. The government program in Canada was folded in the late-1980s and Sandia suffered a similar fate with their verti-

cal wind turbine program. Compared to the horizontal wind turbines, the vertical turbine has had relatively little research; however, in our opinion, it has far greater potential. In the quest for the perfect turbine, the vertical axis model has been overlooked. Some of the advantages of the Lux VAWT turbine include:

- Lower capital cost
- High power output
- Low maintenance with few moving parts
- Low overall center of gravity
- Easy access to ground level power generation
- Gearboxes and generators can be contained in sound proofed ground level facilities to reduce external noise
- Higher power output/land area by using counter rotating turbines in close proximity
- A simple Friction Drive system reduces or eliminates gearbox problems

VAWT are wind direction independent and the turbines offer uncomplicated scalability to smaller or larger sizes with excellent longevity. These are important issues, especially since the warranty period for newly designed and manufactured HAWTs has been decreasing in recent years, despite the fact that the bulk of research money over the years has been put into complex HAWTs. Isn't it time to rethink the direction we are headed?

Predictions for a 2.6MW Lux Wind Turbine	
Operating Data	
Rated Power	2.6MW
Cut-in wind speed	4.0m/s
Rated wind speed	15m/s
Cut-out wind speed	25m/s
Rotor	
Diameter	80m
Height of blades	130m
Equator Height	70m
Total Height	140m
Swept Area	7680m2
Operating Interval	5 to 10 rpm
Speed Increaser	Friction Drive
Blades	
Number	6
Chord Length	1.2m
Material	Auminum extruded 6063 T5
Length (each)	150m
Weight	48kg/m
Rotor Weight	
Blades	43,200kg
Cross Cables	8,000kg
Guy Cables	9,000kg
Top Hub	9,000kg
Bottom Hub (Part of Friction Drive)	N/A
Total Rotor Weight	69,200kg

WIND TURBINE OBSTRUCTION LIGHTING

When International Tower Lighting, LLC considered the particular needs of wind turbine lighting systems, they started from the ground-up and surpassed FAA requirements to tackle this unique need.

By Andy Rudolph, P.E.

Andy Rudolph, P.E. is the vice president of engineering with International Tower Lighting, LLC. Please contact him at arudolph@itl-llc.com or call 615-256-6030 or visit www.itl-llc.com for more information.

WHEN THE ENGINEERING TEAM at International Tower Lighting, LLC considered the unique demands and requirements of obstruction lighting systems for wind turbines, they were venturing into uncharted territory. Among the multitude of challenges, the first key question was whether to modify an existing telecommunications lighting system or to design a lighting system specifically for wind turbines. Extensive industry research and consultation with experts in the field yielded the definitive answer, the designers at ITL responded with the IFH-1710 and built it entirely from the ground up to serve the requirements of the wind turbine industry.

The project began with a careful investigation of the regulatory and environmental factors governing the wind turbine industry. In addition to strict FAA requirements, the wind industry and the wind turbine environment have their own standards and concerns, especially with regard to compliance with environmental stewardship and advanced energy technologies. It was clear that, as with their original telecommunication designs and equipment, success with the IFH-1710 would require strict adherence to the industry's most demanding specifications.

With clear guidelines for designing and manufacturing a light build to surpass the industry's own

standards, the engineering design team set the bar high. They concluded that the ultimate design of the new IFH-1710 must:

- Be highly *energy efficient*;
- Use *sustainable materials and advanced technology*;
- Be *rugged* enough to endure harsh environmental conditions;
- Be *compact* enough for the limited space available on a wind turbine nacelle; and
- Be *flexible* enough to meet the needs and individual requirements of different customers.

What follows is an overview of the criteria that figured heavily in every stage of the design process and how ITL's design team addressed each engineering challenge.

FAA REQUIREMENTS

In tackling regulatory compliance, the team began with the requirements specific to wind turbine farms that may be found in chapter 13 of FAA Advisory Circular AC 70/7460-1K available at www.faa.gov. The FAA defines a wind turbine farm as "*wind turbine development that contains more than three (3) turbines of heights over 200 feet above ground level.*" Not every wind turbine within a farm is required to be lit. The FAA requires unlit gaps of no more than ½ statue mile. FAA Type L-864 red flashing lights are preferred for night-time marking and all lights are required to flash synchronously.

Detailed technical specifications for the L-864 lighting system can found in the FAA Advisory Circulars and Engineering in table 1.

The FAA clearly states that the type L-864 red flashing lighting system is preferred for wind turbine farms, so this made the decision clearly in favor of designing the IFH-1710 as an L-864 that would flash synchronously. To avoid costly cabling between lights, the team elected to use the timing signals derived from the Global Positioning System for flash synchronization. However, further investigation revealed that not all GPS receivers are created equal. Thorough testing of several models resulted in significant differences in the speed and ability to receive the required timing signals under varying environmental conditions. Based on test results, ITL's design team favored use of a one-piece GPS receiver manufactured by Garmin that was found to be extremely fast and reliable at achieving a satellite fix. It was also compact enough to fit inside the cover of the IFH-1710 lighting system.

LED TECHNOLOGY AND OPTICS

Due to their ability to efficiently produce light, LEDs are finding their way into everything from flashlights to street lights. Choosing high power LED technology was one of the design team's easiest choices. However, the companies that manufacture LEDs generally design them to disperse light over a wide area. The light beam of a high power LED can be as wide as 120 degrees. FAA requirement for obstruction lighting systems require a vertical beam of only 3 degrees and heavily restrict the amount of light allowed past 10 degrees below horizontal.

Early on, ITL recognized that an efficient secondary optic would be required to tame the wide LED light beam into the tight "disc of light" re-

quired for a wind turbine obstruction lighting system. So, the IFH-1710 includes custom-designed and molded optical grade PMMA (Acrylic) precision optics coupled with high power LEDs to meet these challenging requirements.

THERMAL DESIGN

The power dissipated by an LED, usually only about 1 watt, may sound quite low. However, this power is packed into a very small space. The light emitting area of an LED, called the die, can be as small as 1mm square. 1mm is about the diameter of the wire used to make a large paperclip. Even a small amount of power in such a small space leads to high power density. If great care is not taken to remove heat from the LED die the temperature will rise. High temperature adversely affects LED life and efficiency, so an effective thermal design is critical to the success of an LED lighting system.

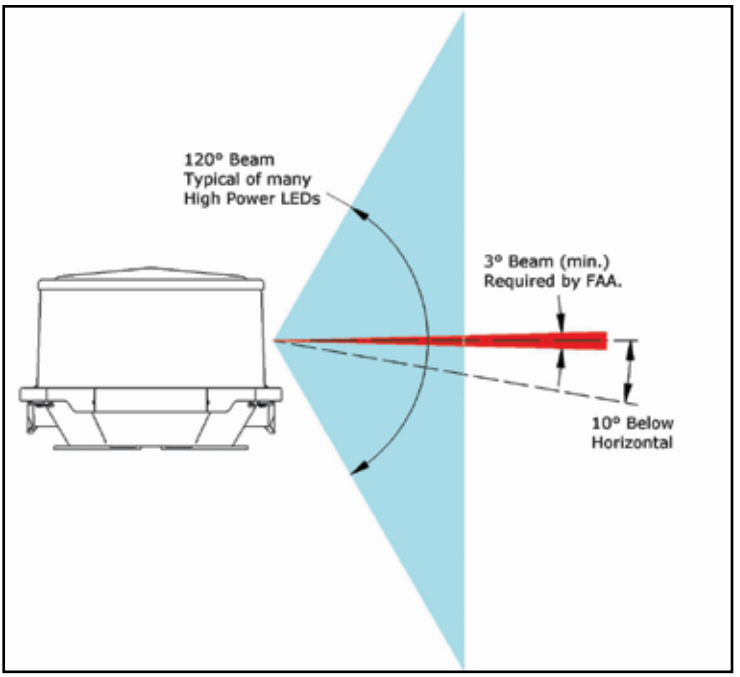

Figure 1: LED beam detail

Traditionally, electronic components like LEDs have been mounted to printed circuit boards, which have a copper layer and fiberglass substrate. Fiberglass is a thermal insulator and therefore, is

FAA Advisory Circulars & Engineering Briefs	
AC 70/7460-1K	Obstruction Marking and Lighting
AC 150/5345-43F	Specification for Obstruction Lighting Equipment
AC 150/5345-53C	Airport Lighting Equipment Certification Program
EB 67D	Light Sources other than Incandescent and Xenon for Airport and Obstruction Lighting Fixtures

Table 1

not well suited for most high power LED designs. Metal clad printed circuit boards (MCPCBs) replace the fiberglass substrate with an aluminum plate. The copper layer is separated from the aluminum by a thermally conductive yet electrically insulating dielectric layer. The resulting metal clad printed circuit board is highly effective at removing heat from the LED.

For their IFH-1710 design, ITL chose metal clad printed circuit boards and mounted them to an aluminum heat sink to efficiently conduct heat away from the LEDs. A rugged cast aluminum base then conducts the heat out of the lighting system.

POWER SUPPLY

The light output of an LED is primarily determined by the DC current flowing through it. So to achieve constant light output, conversion from AC power into a DC current would be necessary.

The two main types of power supplies are the linear power supply and the switching power supply. The linear power supply is simple and rugged but dissipates excess power as heat. This is both inefficient and detrimental to the life of LEDs. Switching power supplies were specifically developed to minimize the production of unnecessary heat and can also be designed to accept a wide range of AC voltage and frequency. This flexibility makes them usable worldwide without modification. These characteristics make the switching power supply an ideal solution for driving LEDs. In the IFH-1710, the switching power supply accepts 120 to 240Vac, 50

or 60Hz to power the LEDs while minimizing the production of excess heat.

SUSTAINABILITY

Aluminum accounts for over 60% of the weight of the IFH-1710. ITL's engineers chose aluminum because of its ability to conduct heat and its sustainable nature as one of the most highly recycled metals in the United States. However, sustainability does not just mean using highly recycled materials and an energy efficient design. Sustainability also encompasses "the capacity to endure." The IFH-1710 wind turbine obstruction light would need to endure.

Wind turbine obstruction lights are subject to extremes in weather, including heat, cold, wind, rain, and snow as well as other factors such as vibration and lightning. While ITL's design makes every effort to prevent failure, it would also need to be repairable. A dispose-of-upon-failure design would not be a sustainable one. To be truly sustainable, the IFH-1710 obstruction light would need to be field repairable. Thus, the design must include accessibility and modularity.

The resulting highly accessible features of the field-repairable design of the IFH-1710 include a hinged cover that uses rugged stainless steel draw latches to secure it when closed. The interior may then be accessed in seconds, while also remaining highly secure and protected from the elements when latched closed.

Further, modularity is achieved as all of the electronics including the controller, power supply, GPS and LED boards are included in a single replaceable assembly called the LED Light Engine. The LED Light Engine is assembled around a custom designed aluminum extrusion. LED circuit boards and optics are installed on the outside surfaces to direct light 360 degrees around. In the center of the light engine

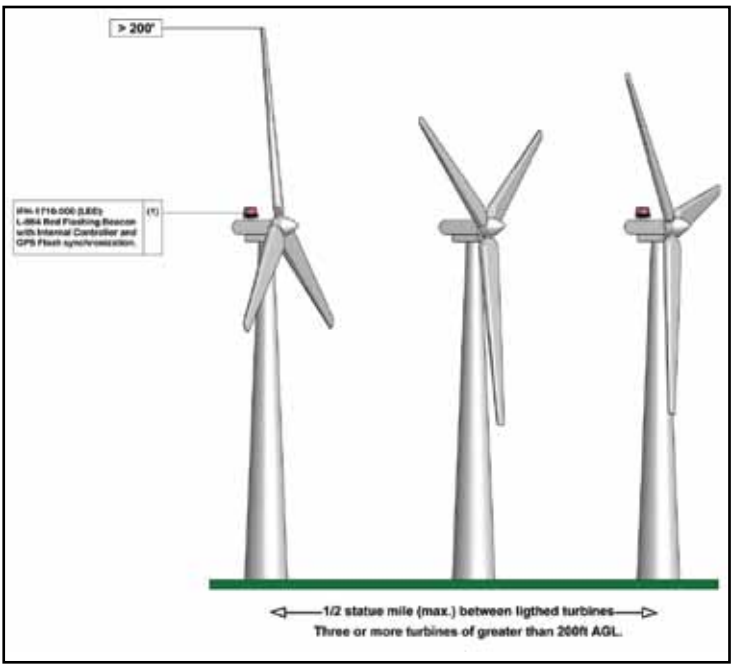

Figure 2: WindTurbine farm with IFH-1710

are two card slots that house the controller circuit board and power supply circuit board. A GPS and photocell for determining day/night operating mode are mounted on top of the light engine. The entire light engine assembly can be removed from the cast aluminum base for servicing by loosening only four fasteners. All of the light engine's components are replaceable.

INSTALLATION

The wind turbine obstruction lighting customer's objective is to produce clean and sustainable electricity from wind, not to provide a home for an obstruction light. With that in mind, ITL endeavored to minimize the size of its wind turbine obstruction light. The resulting design of the IFH-1710 is a complete obstruction lighting system contained within a compact flash head. What this means to the customer is that it requires virtually no space inside the nacelle.

To simplify installation, the IFH-1710 comes with a prewired cable for connecting power and Form-C alarm contacts. For a new wind farm, mounting the flash head and connecting the cable is all that is necessary. For existing wind farms, the IFH-1710 is designed to be flexible enough to match the flash rate of other manufacturer's lighting systems with only the flip of switch.

UNIQUE CIRCUMSTANCE; FRESH APPROACH

Obstruction lighting design is not a one system-fits-all-industries proposition. When venturing from telecommunications lighting systems to those for the wind turbine industry, International Tower Lighting, LLC recognized that the unique circumstances of the industry demanded a fresh design from the ground-up.

Using extensive engineering design expertise in the obstruction lighting field honed over the last twenty years, the company has now introduced its new wind turbine obstruction lighting system in the form of the IFH-1710, addressing exacting standards for energy efficiency, sustainability and ease of installation.

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< Continued from pg 20

INDUSTRY VETERAN TO LEAD NEXT-GENERATION WIND TURBINE COMPANY

Northern Power Systems www.northernpower.com, a next-generation wind turbine company, announced today that Troy Patton has been elected President and Chief Executive Officer. Mr. Patton previously served as President of the Utility Wind business at Northern Power Systems (NPS).

"We are very pleased to appoint Troy Patton as President and CEO of NPS," said John Simon, Chairman of the Board. "Over the past few years Troy has led the successful development of the NPS 2.3MW permanent magnet direct drive wind turbine, and he is an industry veteran who has earned the respect of the Board, our employees and our customers."

Since joining NPS in April 2009, Mr. Patton has served as President of both the Utility Wind and Distributed Wind businesses. He brings over 20 years of experience in the power generation industry. Prior to NPS, Troy was Senior Vice President of Engineering and Products for Vestas Wind Systems. Before Vestas, Patton served in numerous technical and leadership roles at General Electric's Gas Turbine and Wind Turbine businesses.

"I am very excited to be stepping into my new role at NPS," said Patton. "In addition to building our Utility Wind franchise, I look forward to managing the global expansion of our industry-leading Distributed Wind business."

The Board of Directors also expresses its gratitude to John Danner, former President and CEO, and Parthiv Amin, former President, Distributed Wind, both of whom are leaving the Company. Mr. Danner and Mr. Amin were instrumental in leading the success of NPS since 2008 and 2010, respectively.

For more information visit www.northernpower.com.

OPENING DAY NEAR FOR JANNEBY WIND TESTING SITE

The only independent wind turbine-testing site in the German federal state of Schleswig-Holstein will soon be ready to accept its first wind turbines. The test field, which has been developed by GL Garrad Hassan, GEO (Gesellschaft für Energie und Oekologie mbH) and Bürgerwindpark Janneby e.G, received final building approval and will launch testing activities at the end of 2012. The opening of the Janneby site will mark the return of independent testing facilities for wind turbines in Schleswig-Holstein since the end of the 1990's.

The test field is designed for the assessment of new onshore wind turbine prototypes, a crucial part of being able to obtain certification for a new product. The site comprises eight test beds and meets IEC Class II wind condition classification. The average annual wind speed is 7.1m/s at 100 meters high. The testing phase can run up to five years, for turbines of up to 150m in total height.

Manufacturers who choose to use the test field will be able to make use of the full range of GL Garrad Hassan services, including: wind measurements, acoustic, power performance, load, power quality and low voltage ride through (LVRT) measurements. A LiDAR test site is also planned for development.

Photo (f.l.t.r.): Stefan Alexander (Executive Board BWP Janneby e.G), Oke Timmsen (Deputy Mayor Community Janneby), Arndt Folkerts (Verw. GmbH Windpark Janneby), Bernd Hansen (Executive Board BWP Janneby e.G), Jörg Thordsen (Executive Board BWP Janneby e.G), Reinhard Thomsen (Executive Board BWP Janneby e.G), Volker Koehne (Country Manager Germany, GL Garrad Hassan), Olaf Bruhn (Location Manager KWK, GL Garrad Hassan), Michael Schwarze (GEO-Gesellschaft für Energie und Oekologie).

"In the rapidly developing wind energy industry, extensive prototype testing is essential for manufacturers looking to bring new products to the market. Working with globally recognized independent consultants demonstrates to potential clients the verifiable technical quality of a product, which combined with certification, is essential in the industry today," said Volker Koehne, Country Manager Germany, and GL Garrad Hassan.

Independent testing and measurement are keys in increasing the reliability, efficiency and performance of wind turbines, propelling the optimization of existing, and development of future designs to meet the challenges of this burgeoning industry.

For more information on GL Garrad Hassan, please visit www.gl-garradhassan.com.

GE PROVIDES 38 TURBINES TO POLISH PROJECT

General Electric will supply 38 wind turbines for four wind projects in construction in Northern Poland. When operational, these projects referred to as Darlowo Wind Energy Center – Phase Two that mark the first use of GE's 2.5-megawatt class wind turbines that feature 103-meter rotors for high productivity.

Invenergy Wind LLC and Polish development company, Enerco sp. Zo.o. (Enerco) are collaborating to develop nine wind energy generation projects in

the region in and around Darlowo, near the Baltic Sea. GE provided 32 wind turbines for Darlowo – The first phase is fully commissioned and produces 80 megawatts of power.

Darlowo – Phase Two is comprised of the Boryszewo, Krupy, Stary Jaroslaw and Nowy Jaroslaw facilities this will bring the total installed capacity of wind energy in the Darlowo area to 175 megawatts.

Darlowo - Phase Three will consist of two additional projects, Gorzyca and Pekanino, which are currently under contract. These sites will boost the aggregate output of the nine Darlowo projects to 250 megawatts.

"The Darlowo Wind Energy Center is a wonderful example of Poland embracing the economic and environmental benefits of its wind energy resources," said Michael Polsky, president and chief executive officer of Invenergy. "Wind energy is playing an increasingly important role in helping Poland meet its commitments to the European Union with regard to green energy generation."

GE's 2.5 series wind turbines offer high efficiency and reliability for a broad range of wind conditions. Built on the proven performance of GE's 1.5-megawatt wind turbine, the world's most widely deployed machine in the wind industry with more than 16,500 units installed worldwide, the 2.5-megawatt wind turbines with a 103-meter rotor will help the Darlowo projects provide increased energy capacity while maintaining required levels of efficiency, reliability and grid-connection capabilities.

"Darlowo is the result of outstanding regional collaboration between Invenergy and GE," said Stephan Ritter, general manager of GE's renewable energy business in Europe. "Due to the scale of the project, we are establishing a service center in Darlowo to ensure the long-term reliability and performance of our wind turbines." The wind turbines for the Darlowo—Phase Two will be assembled at GE's facility in Salzbergen, Germany. Commercial operation of the turbines is to commence in the fourth quarter 2012.

For more information, please visit www.invenergyllc.com. For more information about GE, visit www.GE.com.

NATIONAL SECURITY AND BUSINESS LEADERS CONVENE ON LAW OF THE SEA

U.S. national security and business leaders, including Secretary of Defense Leon Panetta and General Martin Dempsey, Chairman of the Joint Chiefs of Staff, called the Law of the Sea Convention essential to protect American security and economic interests, guarantee the global mobility of U.S. armed forces, and extend U.S. sovereignty.

"Frankly, this is not even a close call - the Law of the Sea Convention is supported by major U.S. industries, the Chamber of Commerce, our energy, shipbuilding, shipping, and communications companies, and environmental organizations, along with past and present Republican and Democratic administrations and the entire national security leadership," said Secretary Panetta. "Not since we acquired the lands of the American West and Alaska have we had such an opportunity to expand U.S. sovereignty."

Secretary Panetta and Gen. Dempsey spoke to a gathering of U.S. national security and business leaders in Washington, D.C., convened by The Pew Charitable Trusts and the Atlantic Council. Numerous high-ranking former U.S. military officials and a diverse array of business representatives also participated in the forum to discuss the national security and economic merits of the treaty.

"The U.S. Chamber of Commerce strongly supports the Law of the Sea Treaty because it would provide clear legal rights and protections to American businesses to transit, lay undersea cables, and take advantage of the vast natural resources in and under the oceans off the U.S. coasts and around the world," said Bruce Josten, executive vice president for Government Affairs at the U.S. Chamber of Commerce.

"The United States stands with Turkey as the only NATO members that have not ratified Law of the Sea, a U.S.-initiated treaty that protects American interests off U.S. shores and around the world," said Chuck Hagel, a former senator from Nebraska and now chairman of the Atlantic Council. "Senate ratification this year would allow America to take its rightful place and enjoy the benefits and protections of this important treaty."

The treaty would strengthen America's claim to the full outer continental shelf. In the case of Alaska, this would extend U.S. sovereignty 600 miles offshore, instead of the current 200-mile limit. For more information visit www.pewtrusts.com

PSI REPAIR SERVICES TO SHOWCASE OFF-WARRANTY REPAIR SUPPORT AT WINDPOWER 2012 CONFERENCE & EXHIBITION

PSI Repair Services, Inc., a subsidiary of Phillips Service Industries, will showcase its off-warranty repair support for wind energy operations and maintenance (O&M) professionals at the AWEA Windpower 2012 Conference & Exhibition.

PSI Repair Services offers fast, affordable repairs, including upgraded/longer-life products, for out-of-warranty electronic, hydraulic and precision mechanical components that drive your turbines' pitch and yaw systems and down tower electronics.

Components repaired include printed circuit boards, PLCs, control cards, VRCC components, IGBTs, thyristors, converters, pitch motors, hydraulic pumps, servo motors, transducers and much more. All repairs come with a free evaluation and one-year warranty.

PSI uses the latest diagnostic tools to detect failures down to the microchip level. Solutions range from minor component changes to full replacement printed circuit boards, with enhanced designs to improve performance and reliability. These options allow you to significantly increase mean time between failures (MTBF) and prevent costly downtime and/or repeat repairs.

In addition, PSI provides comprehensive remanufacturing services for unsalvageable, obsolete components. Plus, PSI's stocking programs provide fast turnaround to help reduce inventories.

"PSI Repair Services is a one-stop resource for wind farm O& M professionals," said Mike Fitzpatrick, General Manager of PSI Repair Services. "No other repair service provider in the wind industry can match PSI's breadth and depth of cost-saving services, or has a dynamic Engineering Services Department quite like PSI. The difference is clear for our customers."

The AWEA Windpower 2012 Conference & Exhibition takes place June 3-6 at the Georgia World Congress Center in Atlanta, GA. PSI Repair Services will be exhibiting in Booth 1062. For more information visit www.windpowerexpo.com. For more information about PSI Repair Services, visit www.psi-repair.com.

AGY EXPANDS S-2 GLASS MANUFACTURING CAPACITY BY 20 PERCENT

AGY announced today that it has increased production output of its S-2 Glass® fiber reinforcements by twenty percent with the capability to further increase its output as market demands dictate. This expansion enables AGY to meet growth in both the aerospace and industrial markets for high-performance glass fibers used for composite reinforcement.

S-2 Glass fibers are made exclusively by AGY and are supplied to a wide variety of markets and end use applications around the world. In the aerospace industry, S-2 Glass fibers offer unique reinforcement properties that are critical to high performance aerospace applications such as helicopter blades, aircraft flooring, interiors, and structural parts.

AGY offers S-2 Glass fiber products that are designed to be compatible with phenolics, epoxies, polyesters, vinyl esters, rubber as well as many thermoplastic resins. S-2 Glass has tensile strength that exceeds that of standard-modulus carbon fiber as well as most grades of aramid fiber. Because S-2 Glass fiber has a high strain-to-failure of 5.7 percent (compared to aramid's 2.8 percent and carbon's 1.5 percent) it has an exceptional ability to withstand high impact events.

"With this significant increase in output, we are confident in AGY's ability to stay ahead of the needs of the market for S-2 Glass reinforcements," said Drew Walker, AGY President.

For more information about S-2 Glass fibers, please www.agy.com.

POWER GRID 'FRIENDSHIPS' HELP AVOID SOUTH ASIAN POWER DEFICITS

Certain South Asian countries are due to benefit from resource sharing with neighboring nations, as power grids are planned to help spread the growing electricity demand in the region, according to energy expert GBI Research.

The new report states that the continuously increasing demand for power is stemming from rapid industrialization and commercialization in the South Asian region, with the resulting imbalance in the electrical demand and supply scenario representing the main driving force behind the growing power sector in South Asian Association for Regional Cooperation (SAARC) countries. The major SAARC countries in terms of power demand include India, Pakistan, Afghanistan, Bangladesh, Bhutan, Nepal and Sri Lanka.

SAARC member countries are also planning to trade electricity with one another, with plans underway to develop a robust cross-country power grid. Plans are also underway to set up 200km of submarine cables between India and Sri Lanka to deliver 1,000 megawatts (MW) of electricity. Import and export of power between SAARC countries at competitive rates will act to support the region, offering aid in cases of power deficits in any member country. Some cross-border trade is already in place, with Bhutan exporting around 1,200-1,400MW of electricity to India's power grid.

The power markets of almost all SAARC member countries are regulated by state powers and, some private players are present in the generation and transmission segment, the sector is currently largely closed to competition. However, increasing electricity demands and a need to improve power infrastructure has led governments in SAARC countries to formulate lucrative policies offering incentives to private players for their investment.

The power market in many SAARC countries now invites Foreign Direct Investment (FDI), which will assist countries in developing better infrastructure, providing a more reliable power supply to its citizens and minimizing power shortages.

The cumulative installed capacity for power in the major SAARC countries is expected to grow at

a compound annual growth rate (CAGR) of 8.6% to reach 505.7 gigawatts (GW) in 2020. Thermal resource based installed capacity is expected to grow at a CAGR of 5.8%, while renewable and hydro sources are expected to grow at respective CAGRs of 16.9% and 9.3% doing the next decade. Nuclear power installed capacity is also expected to grow at a CAGR of 17.6% throughout 2012-2020.

RWE INNOGY TO BUILD FOURTH WIND FARM IN POLAND

In Nowy Staw, near the city of Gdansk, the first construction vehicles will soon arrive on site, marking the start of construction for Innogy's fourth wind farm in Poland. Nineteen wind turbines manufactured by REpower Systems SE with an overall installed capacity of 39 megawatts (MW) will be built over an area of 15 square kilometers. If everything goes according to schedule, the wind farm will be commissioned as early as the beginning of 2013 and will supply an equivalent of more than 50,000 homes with green electricity every year. The investment volume amounts to more than 60 million Euros.

"With Nowy Staw we are expanding our wind portfolio in Poland by almost 40 MW. This will bring us a great step closer to our goal of adding 50 MW of wind capacity in Poland every year until 2015. Our Polish wind pipeline is well filled. All in all, Innogy plans to have around 300 MW in operation in Poland by 2015", said Prof. Fritz Vahrenholt, CEO of RWE Innogy.

Andreas Nauen, CEO of REpower Systems SE, commented: "With Nowy Staw we are implementing our largest project in Poland so far. The site in the north of the country with its average wind velocities is optimally suited to accommodate the REpower MM92 turbines. To date, we have installed more than 2,000 plants of the MM series all over the world. We are delighted that RWE Innogy has put its trust in our proven technology and has once again chosen REpower as supplier."

RWE Innogy is already operating three wind farms with a total capacity of approx. 108 MW in Poland: Suwalki, Tychowo and Piecki. Apart from the actual construction work on site, the company will also develop the local infrastructure around Nowy Staw. This includes repair and modernization work as well as the building of three kilometers of new roads, which becomes necessary due to the wind farm construction. The next development stage for the onshore wind farm Nowy Staw has already been planned for 2013.

Electricity generation from renewable sources is currently supported via a system of "green certificates" in Poland. Electricity suppliers are obliged to offer a certain percentage of the energy fed into the grid from renewables. They can comply with this obligation by acquiring additional "green certificates." For more information visit www.repower.de.

EIP FILES FOIA SUIT TO OBTAIN DETAILS ON 65 CLEAN AIR ACT MEETINGS

The Environmental Integrity Project (EIP) filed suit late Tuesday under the Freedom of Information Act (FOIA) to obtain records of 65 meetings that the White House Office of Information and Regulatory Affairs (OIRA) held with interest groups to discuss four major Clean Air Act rules under consideration by the Environmental Protection Agency (EPA).

The scope of the EIP lawsuit includes 51 meetings with representatives of utilities and other industries, and 14 with public interest organizations.

The EPA rules in question are: the Mercury Air Toxics Rule; the Ozone Rule; the Boiler Rule; and the Cross-State Air Pollution Rule. OIRA's website maintains a list of meetings and attendees for each pending rulemaking at http://www.whitehouse.gov/omb/oira_meetings.

EIP Attorney Alayne Gobeille said, "We are filing the suit because we have received no response from OIRA to our original FOIA request of January 24 2012, although the law requires to agency to respond within than 30 days." Executive Orders put in place by President Clinton and reaffirmed by President Obama require the records of any meetings that have a significant impact on regulations to be made publicly available as part of the rulemaking record.

OMB's website identifies attendees and posts written materials presented at these meetings, but provides no information about the substance of the discussion. No materials were provided at 16 of the meetings in question, including four attended by OIRA Administrator Cass Sunstein, leaving the public no clue about the content of those conversations. "Industry lobbyists have every right to meet with the White House about EPA rules," said Gobeille. "But the public ought to know what was said at these meetings and whether it influenced decisions that are supposed to protect our health and the environment."

Gobeille adds, "OIRA has clearly emerged as a major chokepoint when it comes to regulations that affect the public health, hosting no fewer than 123 meetings related to EPA regulations alone in 2011, including those pertaining to solid waste and the Clean Water Act. Most of these regulations are required by statute and subject to court order requiring their completion. Reasonable people may disagree about the role that OIRA should play in these reviews, but all parties should agree that meeting records that include a summary of discussion should be part of the public record to inform debate about proposals and final decisions." For more information, visit www.environmentalintegrity.org.

ADINDEX

Charles Clayton
Training Manager /Suzlon Wind Turbine Training Center

TELL US ABOUT THE TRAINING CENTER.

The Wind Turbine Training Center opened October 2011 and is located in Elgin, Illinois, near our North American headquarters in Chicago. Suzlon's Chicago office is the corporate center for sales, marketing, business development, supply chain services, maintenance and our Suzlon Monitoring Center, which is staffed with technicians and engineers 24/7 to monitor more than 1,800 turbines in North and South America and Europe. The Wind Turbine Training Center features a 4,000-square-foot lab, as well as an 8,000-square-foot facility which houses North America's only fully operational wind turbine dedicated exclusively for technician training. The Center is also equipped with a powered independent hub and pitch system to allow for simultaneous training on nacelle and hub. The turbine is completely functional and designed for "working-at-heights" and simulating on-the-job experiences working on top of turbines.

HOW WAS THE DECISION MADE TO INVEST IN A DEDICATED TRAINING CENTER?

We felt we needed to improve our training and offer fully functional turbines at full-scale to perfectly mimic the real world, and a place we could show employees and customers how to work safely on a turbine. We are able to show them how a turbine system is broken down into smaller, modular systems that support a philosophy of ideally teaching component systems and interaction with the entire turbine. Suzlon training works hand-in-hand with our industry-leading Safety division that has been recognized by our customer Duke Energy with a safety award two years in a row.

WHAT MAKES YOUR FACILITY UNIQUE?

Our facility allows us to apply real world safety scenarios. Safety for all site workers is our paramount goal and we can show trainees how every aspect of the job can be done safely; whether it's working at heights, electrical or mechanical. Our facility contains a fully functional turbine, and several training stations. Control of the blade angle is a critical function in any turbine and we have a separate, fully operational pitch system complete with PLC, slip ring and hub system. Stations dedicated to motor control and alignment allows us to introduce concepts, which are then perfected in our live turbine. The turbine serves many functions for Suzlon: teaching safety in a real world environment where our trainees practice every phase of rescue, while our engineering department can use the turbine for research and product improvement. Most importantly, the 2.1-MW capacity turbine allows our technicians to directly apply what is learned in the classroom and on the training stations to the turbine, in an atmosphere identical to what they will see every day on the job.

Our philosophy is that training never stops! Before any prospective employee can work on a Suzlon turbine they must attend Entry Level training where they will be met with four points of focus: general safety, electrical safety, working at height safety and basic turbine operation. Upon completion technicians go to a site for a period of four months. While on site technicians continue their education by working on an electrical/electronic self-paced training system manufactured by the Nida Corporation. This system offers complete lessons and a hands on platform to enrich a technicians understanding of electrical principles. New technicians are also enrolled in our e-learning system, which offers more safety and technical training modules. After four months at a site, technicians return to the Training Center for Level Two training. Level Two offers extensive work that includes in-depth software diagnostics, line by line schematic training, troubleshooting and understanding software and again, direct turbine interaction. Module programming and component alignment are also extensively trained. Suzlon's next module is scheduled at the first anniversary of employment when technicians return for a deep dive into sub-system specialization. Even in the highest levels, technicians continue learning about software, troubleshooting, mechanical, and system functions.

Most major OEMs have training programs, but I think Suzlon is the only company that insures that a prospective employee comes to the center and masters five levels of validation in the first weeks of pre-employment. If a person fails any part of that training they are not allowed to work for our company. These rigors allow Suzlon the certainty that prospective employees understand the hazards involved in this type of work, the importance of personal protection equipment and the skills they need to be a safe worker. In our company if you work around a turbine you must be knowledgeable in ALL areas, which I think is unique in the industry. We believe as long as a worker is working on any part of the turbine, they need to know how all systems work and how to protect themselves in every situation. Our training is set up in practicable tests that teach a student how to troubleshoot for problems. They are time tested and have three chances to find three problems in the allotted 20 minutes, using schematics.

Call (773) 328-5077 or visit www.suzlon.com for more information.

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