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WIND SYSTEMS

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- Managing Drivetrain Health: Knowledge is Power, Time is Money
- Making Sense of the CMS Market
- Breaking the 34.5kV "Standard"
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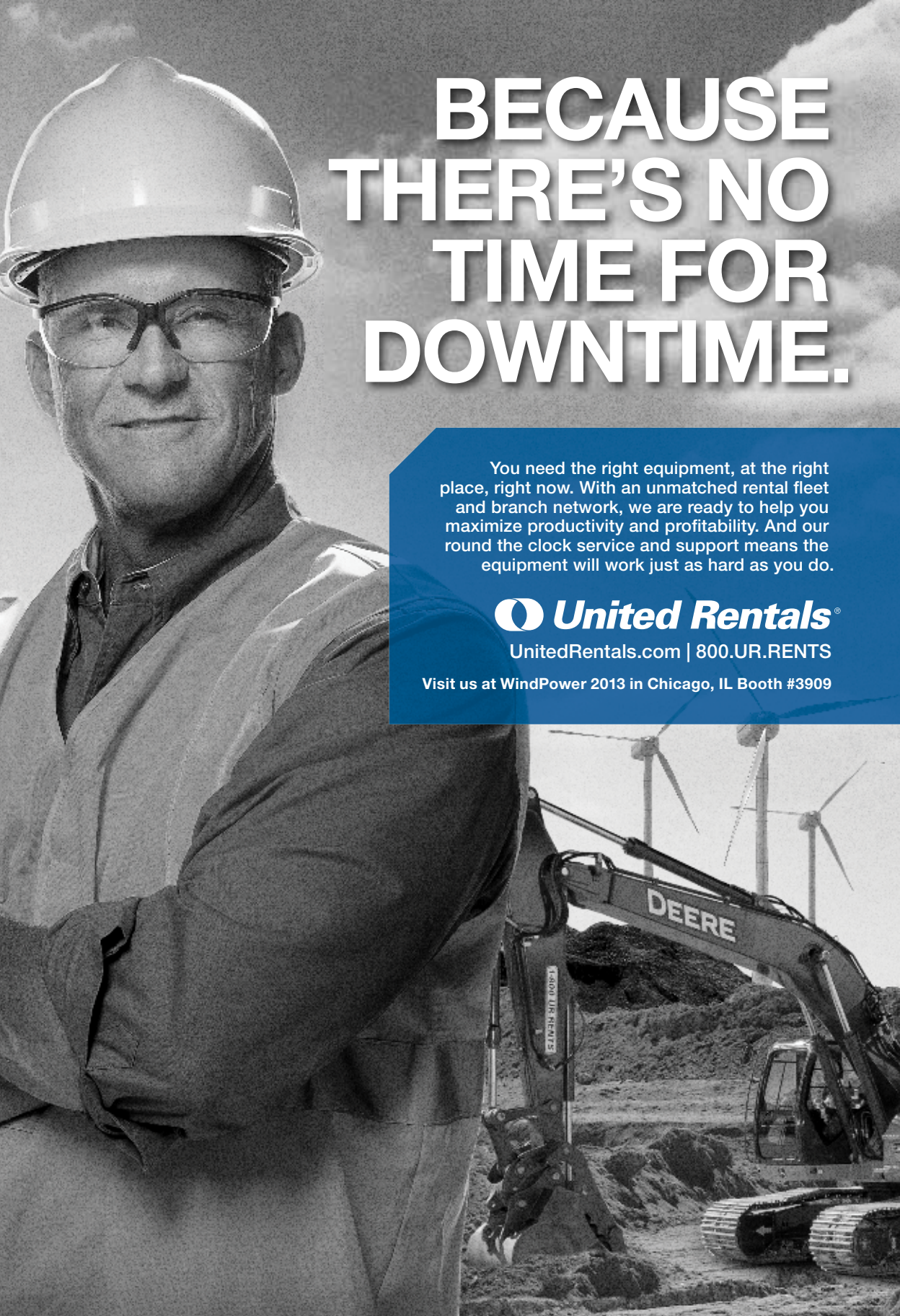
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EDLETTER

I never was the new kid. Never had to change school systems or totally re-acclimate.

The nearest experience for me was transitioning to high school. Many kids had older siblings who could offer advice; but at that point, my (significantly older) brothers were establishing their adult lives.

I was relegated to undertaking my harrowing journey solo. No safety net. No survival guide.

(Note to self: Formulate "High School Preppers" reality show proposal. Pitch to expanded basic cable channels.)

I don't recall my first day of high school. My psyche must have repressed those memories. But I'm still here. I survived.

Fast-forward two decades, and WINDPOWER 2013—my inaugural trade show—is a month away (May 5–8 in Chicago).

I finally get to be the new kid; and claiming I'm completely at ease with that would be a lie. The anxiety has set in—and it's not the good kind of anxiety (e.g. first dates; staying up for Santa; riding to Wally World in the backseat of the Family Truckster). I'm talking about the classic "sweaty palms; can't find my locker; praying I don't get beaten up," all-out panic. Terror threat: "Severe."

(A side note: I find it cruel that AWEA has chosen to place a countdown clock at the top of the event website. At any given time, day or night, I can log on and know the precise number of days, hours, minutes, and seconds remaining until my impending doom. Thanks, guys!)

I do take some comfort, however, in the fact that my colleagues sense my anxiety and have graciously begun to offer their support and advice. *Wear comfortable shoes... Have a plan... Don't zigzag... Stick to your schedule... Try not to get overwhelmed.* I know they mean well. Still, much like a coltish older sibling, the hint of a wry smile appears when one of them recounts past "horror stories."

So what's my game plan? After an objective examination, I'm adopting the following: "Know what to expect; and expect the unexpected." Perhaps engaging wholly in the experience will squelch the anxiety and make for a great event. All joking aside, I'm actually pretty psyched about the networking and educational opportunities the event will provide. I can't wait to meet as many of our readers, contributors, advertisers, and yes, even competitors, as possible at the event.

We're trying to keep the interactivity level high, so please connect to our Facebook (/windsystemsmag) and Twitter (@wind_systems) for regular dispatches each day of the show.

This issue, we have a hefty article offering provided by a premier sampling of WINDPOWER 2013 exhibitors. These contributors are household names within the industry—GE Power & Water, NRG Systems, Acciona Windpower, and Castrol Industrial, to name a few. If you plan to attend WINDPOWER 2013, please take a few minutes to visit our contributors' and advertisers' booths.

While you're at it, stop by and see us at Booth 5009. Copies of the magazine will be available and we will have daily giveaway drawings. If you're lucky, you might even get a chance to mess with the freshman. I only have one request: No wedgies, please!

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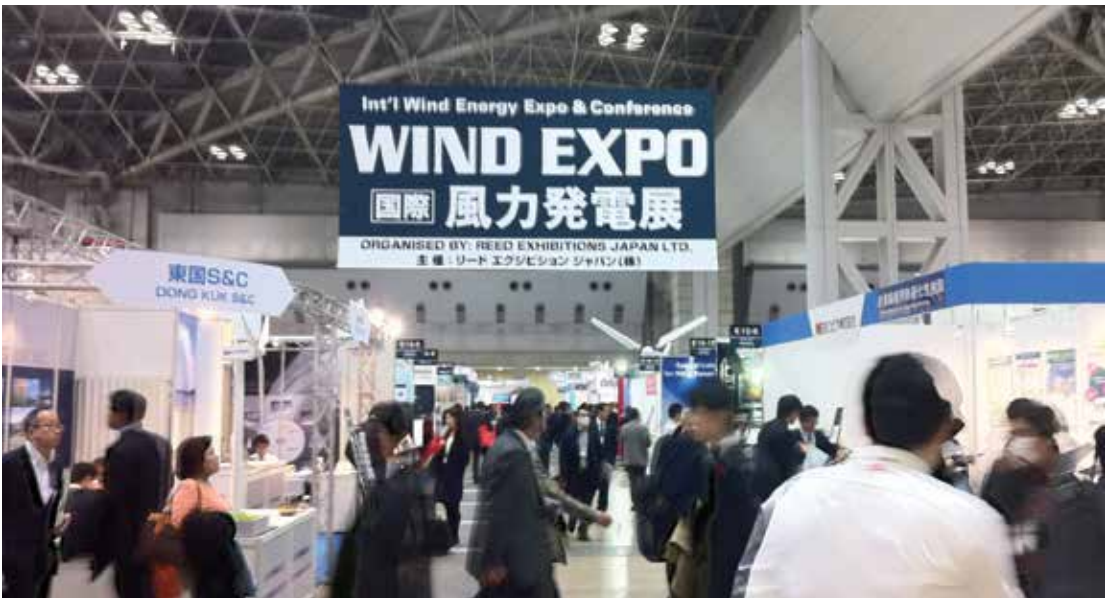

INAUGURAL WIND EXPO IN JAPAN GENERATES RESPECTABLE INTEREST, PARTICIPATION

With renewable and green energy sources making global headway in recent years, surging interest has spawned an increasing number of renewable energy conferences and exhibitions. While everyday consumers can make small changes to reduce their carbon footprint, the most marked impact can be seen when the industry starts implementing green technology. In order to stay current on technological innovations, as well as perform routine business functions such as networking, the industry relies on expositions and conferences.

Throughout Asia, industry leaders have, for a number of years now, turned to World Smart Energy Week, hosted by Reed Exhibitions.

The 2013 event was held February 27–March 1 at Tokyo Big Sight. Due to high demand, the inaugural WIND EXPO was added to the event this year. Participation in the WIND EXPO was more than respectable considering the infancy of that portion of the conference.

"We started FC (fuel cell) EXPO in 2005 and kept launching new exhibitions—PV (photovoltaic) EXPO, BATTERY JAPAN, International Smart Grid Expo, Eco House & Eco Building Expo," Tad Ishizumi, president of Reed Exhibitions Japan said during the opening ribbon-cutting ceremony. "And in the ninth year, WIND EXPO is newly launched. Therefore, we welcome a record number of 1,890 exhibitors as one of the world's largest of its kind."

Among the organized events at the WIND EXPO portion of the event were technical conferences and product and technology seminars, in addition to the exhibition and the keynote sessions. The keynote session was held at 2 p.m. local time on February 27, and was entitled "Industry Leaders' Strategies and Outlook on Wind Power Generation."

As a whole, more than 76,000 attendees attended World Smart Energy Week. More than 11,000 participated in seminar sessions."

Occupying a substantial section of the east hall at the convention complex, WIND EXPO was filled with attendees. More than 100 exhibitors from across the globe eagerly promoted products, services, and technologies that ran the gamut of wind energy production and associated industries. No known segment of the industry was left unserved by the exhibition..

Innovative wind turbine design was displayed prominently, as were energy-conservation components. Short tutorial demonstrations of various types and brands of safety gear and its' proper use were presented several times an hour.

A primary event focus was the development of, and the large, timely technological advances in making offshore wind farms a substantial source of energy within the Asian markets—Japan in particular.

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

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Varied design approaches were offered by different exhibitors, but the prevailing and most-popular topic centered around offshore floating wind turbines. Many of these platform designs combined wind and solar energy technologies as a viable, sustainable, efficient means for green energy generation.

Of particular interest among those in attendance was Fukushima Forward, which seeks to replace traditional energy sources with offshore wind farms located in the ocean. These turbines would collect wind and solar energy and then redirect the collected power to a central hub that could then convert the power to be used across Japan. If successfully implemented, the plan would serve as an example to future energy projects on the viability of offshore wind energy as an option when seeking to replace aging, unsustainable power supply methods.

In its inaugural event, the WIND EXPO was a resounding success at introducing new technology and providing vital networking opportunities within the field. Attendees and exhibitors alike appeared eager to make new business connections and to learn about new technologies. Foundations have been laid to make future shows larger and more successful.

For more information on WIND EXPO and World Smart Energy Week, please visit www.wsew.jp/en.

— By Meghan Hall

INDUSTRY TO GATHER IN CHICAGO FOR ANNUAL WINDPOWER CONFERENCE & EXHIBITION

Wind energy industry leaders, academics, and professionals will convene in Chicago on May 5–8 at the American Wind Energy Association's annual WINDPOWER Conference & Exhibition. The 2013 event, which will be held at McCormick Place Convention Center, is expected to draw nearly 600 exhibitors, consisting of manufacturers, developers, contractors, consultants and service providers.

According to the association: AWEA WINDPOWER Conference & Exhibition is the annual focal point for those who work in the wind energy industry; it's where serious wind professionals convene to grow their companies, find real solutions to business challenges, learn from industry leaders and experts, discover the latest in industry products and services, and reconnect with colleagues and friends.

The event is built around a three-pronged approach to serving wind energy industry companies and personnel. Areas of focus are: networking; education; and exhibition/sponsorship. The association describes these areas of focus as follows:

- Networking– A unique aspect of WINDPOWER is its focus on networking, and the numerous special events that allow attendees and exhibitors to grow and maintain their personal and professional contacts in fun, ca-

sual, and entertaining settings. Each networking event is an excellent networking opportunity, and a great way to spend quality time with staff, colleagues, and industry peers. From receptions in the exhibit hall, to dinners in Chicago's favorite venues, to golf tournaments... there's no shortage of ways to connect with your fellow attendees.

- Education– Each year, AWEA collaborates with wind industry leaders to ensure the WINDPOWER Conference Program is relevant and illuminating. And this year, AWEA is making a concerted effort to build a WINDPOWER program that provides attendees with real solutions to today's serious business challenges. The Conference Program will prepare attendees for facing a changing wind energy future, strengthening our economy, and developing a sound, profitable energy market. As a venue to discuss perspectives, methods, and strategies for maintaining and increasing profitability in an environment of technical, economic, and political change, WINDPOWER is the best place to obtain this knowledge.
- Exhibition and sponsorship– The Exhibition Hall at WINDPOWER 2013 Conference & Exhibition will be the one place to see the industry's leading products and services, learn industry brand names, network with top-level industry decision makers, and generate numerous high-quality business leads. WINDPOWER sponsorship generates unmatched exposure that helps establish your company as a market leader. Sponsorship provides a clear platform for company and product promotions, leaving a lasting impression on event attendees.

Regular registration for the WINDPOWER 2013 event is currently open, and will remain open through the conference. Attendees who register prior to the event will not be charged additional fees for on-site registration.

For more information on WINDPOWER 2013 Conference & Exhibition, including registration information, exhibition, conference schedule, lodging, and special events, visit the event website at www.windpowerexpo.org. For more information about the American Wind Energy Association, please visit www.awea.org.

Editor's note: Wind Systems *magazine is a media sponsor for WINDPOWER 2013 Conference & Exhibition.*

IRON WORKERS FILL THE NEEDS OF EXPANDING WIND ENERGY SECTOR

With more than 40,000 active wind turbines across the country and new construction in 29 states, the Iron Workers, IMPACT, and the Apprenticeship and Training Department are exhibiting their commitment to Wind Turbine Training in a bid to fill the needs of the constantly expanding green energy sector.

Currently, six Iron Worker Local Unions across the United States offer Wind Turbine Training classes, and the program continues to grow.

In November 2012, Iron Workers Local 22, Indianapolis, announced the addition of hands-on wind turbine training at its apprenticeship and training facility as part of an ongoing effort to better serve the construction industry's demands for green energy projects in the region.

Iron Worker wind turbine training courses date from 2010, when the Department of Labor (DOL) awarded the Ironworker Management Progressive Action Cooperative Trust (IMPACT) and the Iron Workers Apprenticeship and Training Department a grant under the green energy training partnership. IMPACT used the grant to set up the first five training programs, under which 629 Iron workers received training.

According to Lee Worley, Executive Director of Apprenticeship and Training, more locals are stepping up to fill the wind turbine erection needs of communities and construction companies. "The DOL grant ran through January 2012, but locals—like Local 22—have indicated that they are more than willing to make the investment in setting up their own training." At $45,000, the price tag for all the required training equipment isn't cheap, Worley explained.

"All of our locals are serious about safety and training to meet the needs of the wind energy industry," said Iron Workers General President Walter Wise.

Iron Workers remain committed to fulfilling the needs of green energy partners, Wise said. "With the expansion of our wind turbine training capability, the Iron Workers will be able to meet the demands for safe, qualified wind turbine erectors throughout our country."

Under an agreement with the National Training Fund, each Local offering Wind Turbine Training must train a minimum of 30 Ironworkers per year.

The following Iron Worker Locals have Wind Turbine Training programs in place:

- Local 6, Buffalo, N.Y.
- Local 27, Salt Lake City
- Local 263, Dallas/Fort Worth
- Local 433, Los Angeles
- Local 444, Joliet, Ill.

For more information about Iron Workers Wind Turbine Training, visit www.impact-net.org.

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SIEMENS OPENS WORLD'S LARGEST WIND TURBINE R&D TEST FACILITIES

Siemens Energy has opened two major Research & Development test facilities for wind turbine technology in Denmark. The new test center in Brande features test stands for major components of Siemens wind turbines, including generators, main bearings and complete nacelles. In Aalborg, seven blade test stands are capable to perform full-scale tests of rotor blades, including the world's largest blade in operation with a length of 75 meters. In combination, the two facilities form the world's largest R&D test center for wind turbine technology.

"Our investments in testing today will result in savings for our customers tomorrow," says Felix Ferlemann, CEO of the Siemens Wind Power Division in Siemens Energy. "With our extensive tests of all major components of a wind turbine we can significantly reduce the risk of technical issues in the field. Our continued commitment to R&D and testing enables us to deliver wind turbines that are both the most innovative and the most reliable at the same time."

The two test centers in Denmark feature indoor testing facilities of more than 27,000 square meters. The nacelle test stands in Brande are among the most advanced in the industry. They are capable of testing Siemens' D6 direct drive platform, the company's largest current wind turbines with a six megawatt rated capacity, and are prepared to test even larger turbines.

The seven blade test stands in Aalborg and three blade tests stands in Brande together form the largest blade test facility in the world both in size and in scope. The Aalborg facilities are able not only to fully test Siemens' 75-meter long B75 blade, the largest wind turbine blade in operation, but also even larger blades. Wind turbine blades are now bigger than any other composite structure in the world. For example, the wing of an Airbus 380 is less than half as long as the B75 blade.

In its new test facilities, Siemens can perform Highly Accelerated Lifetime Tests (HALT) on all major components of its direct drive and geared wind turbine platforms. In HALT testing programs, which can last to up to six months, Siemens exposes prototypes to much higher loads than they would normally experience over the course their full lifetime in the field.

"In HALT tests, we compress the biggest loads over a short time, as they affect the turbine the most," says Siemens Wind Power CEO Ferlemann. During the HALT test of blades, for example, full-scale prototypes are oscillated at larger deflections than they would ever experience on site for 2 million cycles vertically and then for another 2 million cycles horizontally.

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Julian Bell
Signal Energy Constructors

A wind project construction and design checklist for owners to ensure overall safety and meet the project's economic expectations.

SUCCESSFUL WIND PROJECTS don't just happen. They result from the efforts of a large number of talented people over several years. However, the overall success of a wind project can be threatened if successful project development is not followed by successful design and construction. A successful wind construction project can be described as follows: Everyone goes home from the project site safely every day, and the construction allows the project to realize its owners' economic expectations. What are the key attributes of a successful wind construction project? Let's explore a few.

SAFETY

Successful wind projects have great safety records and employ systems that ensure that every person that works on the project goes home safely each day. Wind projects can be dangerous and people can be seriously injured or killed if care is not taken to protect them. A wind contractor's devotion to safety must do more than make the contractor the "safety police." Wind projects constructed by companies with a corporate culture centered on safety and a true concern for the well-being of their workers operate more safely, more efficiently, and have fewer issues in the interfaces between trades. The key is incorporating safety into every aspect of the project, from the initial planning to completion. Projects where workers from all trades are acquainted with each other and have a concern for one another's safety have great safety records, higher efficiency and quality, and great communication between all parties.

THE RIGHT DESIGN

Successful wind projects have system designs that match the economic expectations of the owner. Project success begins with the right project design. Minimalist designs have lower construction costs, but higher than normal maintenance costs and shorter lifespans. Designs that are too robust have lower maintenance costs, but higher than necessary upfront costs. The overall project design should be completed by contractors and engineers that understand the technical aspects of the design, but also understand the installed cost of each system and the overall project economics. Within its economic constraints, a wind project should be designed so that it has the best chance of meeting or exceeding its power output goals for its intended life. The cost of each designed system (civil, structural, and electrical) must fit within the overall economics of the project over its expected life. Each system's design should balance upfront costs with impacts on power production over the plant's lifespan. Contractors and engineers that are active in the wind industry have developed highly effective design criteria for each major system. However, it is not uncommon to see projects built with technically sound designs that unnecessarily add millions of dollars to the overall construction costs. In addition, it is not uncommon to see wind projects with critical failures in design areas resulting from inadequate designs. The best insurance against this happening on a wind project is to engage an experienced wind contractor early in the design process to provide, or guide, the project design.

THE RIGHT TEAM

Successful wind construction projects are built by experienced and knowledgeable teams. Wind design and construction projects are fast-paced and demand quick action. When everything comes together to give a project a green light (interconnection approval, turbine supply agreement, permitting, financing), design and construction must move fast. Missing completion dates can cost the owner millions of dollars. An experienced design and construction team is accustomed to this fast pace and will provide a high quality design/build the product in a relatively short time frame. Experienced wind contractors assemble the team of engineers and trades that have the necessary depth of wind construction experience under a wide variety of circumstances. Additionally, successful wind construction teams have the depth of resources to pull from when issues threaten the completion of a project, particularly in the critical choke points of turbine erection and substation construction.

OPEN COMMUNICATION

Successful wind projects have open, consistent, and effective communications. While no one involved in a project expects its design and construction to be without difficulties, they rightly expect that difficulties will be thoroughly discussed at the appropriate levels, that solutions will be developed in an open manner, and that these solutions will be effectively executed by the contractor. Establishing communications processes and expectations early in a project pays off greatly when unexpected difficulties arise. It's easy to have open communications when everything is going smoothly. It's much harder when issues arise that demand quick responses with input from a number of affected parties. Success hinges on having an effective and functioning communications structure in place when critical issues arise.

When a project design/construction team is assembled, owners will benefit from taking the time to ask their contractors and engineers how their design and construction strategy will make the project a success.

Julian Bell is the director of preconstruction for Signal Energy Constructors. For more information visit: www.signalenergy.com


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THE BASIC STRUCTURE OF A BLADE is made with adhesive, strings, and ropes. If you take a rope and give one end to your dog and you hold onto the other end, you could pull him around the shop. But if you took the same rope and tried to push him with it... Well, I don't have to tell you how well that would work. The rope has its strength in tension. In a wind turbine blade, we place the fibers in specific directions so that we gain the strength of the fibers while in tension. That is one of the important things that a blade technician has to consider when working on a blade. It is important to place the fibers in the proper direction.

Wind turbine blades have complex airfoils designed to efficiently extract energy from the wind. Blades are the one component that are exposed to the elements all day, 365 days a year. The blades run with varying loads composed of structural and aerodynamic loading. These blades take a beating. Sometimes people try to relate wind turbine blades to airplanes, but as a friend of mine says: "You would be pretty amazed if you saw an airplane doing cartwheels all day and survive." The loads for the two are not the same.

It would be great if, during maintenances, you could easily access the blades so that you could inspect them closely. The best that most groups can do is to scan the blades with binoculars, spotting scopes, and high-powered cameras. This does work to catch some issues but it is not the same as being right up on the blade itself. But as you know, to access the blades today take specialized skills or specialized equipment.

As a team member of a wind farm service crew, you should be constantly listening to the turbines. The noises that you should be familiar with include the noises from the blades. Any changes in noise from the blade require investigation. The best technicians are always looking at the blades from the ground and are also always looking at the blades while they are up on top of the machine.

For some reason, most blades built today seem to need leading edge protection. The leading edges of the blades are sometimes eroded away during operation. Due to this problem, there are companies that offer products and services to install a variety of options for leading edge protection (LEP). There is one option for the application of a protective tape which is very durable and resistant to erosion. Another option involves applying a liquid paint-type protection that is also resistant to erosion.

In my experience, the tape works well when it is applied in the shop, under a controlled environment. Installing the tape in the field has been hit-and-miss for me. I have seen LEP tape that was installed in the factory 10 years prior and is still working great. I have also seen field-applied tape torn and making noise within less than two wind seasons. The problem with tape is: If it does tear or lift an edge, it gets noisy. You can't tell if the noise is coming from the tape, or from physical damage on the blade. Personally, I don't fret very much over noisy tape. "Is it torn tape or real blade damage?" Torn tape can result in an on blade inspection by crane or rope. We have yet to see a liquid LEP product produce the same disturbing noise when it begins to fail.

"As a team member of a wind farm service crew, you should be constantly listening to the turbines. The noises that you should be familiar with include the noises from the blades."

The liquid LEP seems the easiest applied in the field but it too has its drawbacks. The primary challenge with LEP is that the protection has to be applied properly and uniformly. It would be nice if you could take the time to remove any ridges left by tape or brush marks. The original airfoil didn't have these ridges.

Small changes in the airfoil affect its efficiency and ability to extract energy. This affects AEP.

Proactive operators will install LEP before damage happens to the blades airfoil. Other operators wait until after damage happens and then install the protection. Those who wait until the damage happens tend to pay more. This is because before the LEP can be applied, the damaged area has to be repaired and shaped. If the airfoil was damaged/increased drag entered the equation, energy production and subsequently money has already been lost. The losses of production are realized in the less-than-rated output portion of the power curve. If the operator waits long enough, secondary damage can occur to the blades' composite structure and more significant repairs may be needed.

With blades, it pays to be proactive.

Jack Wallace is director of wind turbine technical services for Frontier Pro Services. He can be contacted at jwallace@frontierpro.com. For more information on Frontier Pro Services, visit www.frontierpro.com

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By Anders Voldsgaard Clausen
Hempel A/S

Corrosion protection for offshore wind turbines, due to constant exposure to a highly corrosive environment, requires proper resources and painstaking attention to developing an action plan.

MULTIPLE PARTIES ARE INVOLVED in the delivery of successful corrosion protection of offshore wind turbines. The steel builder, paint applicator, and paint supplier are all involved in the process. They must work closely together to achieve the best results.

Corrosion protection is always the last step of the production process. When a job is behind schedule, there is often pressure on the paint shop to make up for lost time. However, trying to gain time by rushing the painting process can have costly consequences. The cost of painting offshore structures in a paint shop is $20–$32 per m^2, depending on the setup of the workshop and the paint system. If repair work must be done offshore due to premature failure of the corrosion protection, the cost can be 40–60 times higher.

Onshore exposure implies generally cyclic dew/condensation and moderate exposure to sunlight, resulting in moderate corrosion at holidays, weak points, and damaged areas of the coating system. In contrast, offshore exposure implies long-term exposure to humidity with high salinity, intensive influence of ultraviolet light, wave action and the presence of a splash zone area, and high corrosive stress resulting in speedy corrosion at holidays, weak points, and damaged areas of the coating system. This difference in exposure severity is also reflected in the mass and thickness loss per unit surface of low-carbon steel and zinc in the first year of their unprotected exposure. For example, in Germany the onshore corrosivity is evaluated as being about C3, according to ISO 12944, which corresponds to a thickness loss of 25 to 50 µm. In comparison, for splash zone areas, as much as 500 µm1 thickness loss has been observed in the first year of service.

A qualified coating system is not enough to guarantee a successful corrosion protection. Other important factors include the design of the structure (access possibilities), the design of edges and weld seams, the workmanship of the applicator, the specific condition of the steel before surface preparation, and the exposure of the paint system immediately after completing application.

The design and fabrication of steel used in wind turbine construction are critical aspects of the corrosion protection of the steel. Before the applicator starts his job, the steel builder has to provide a structure that is suited to be painted successfully. Coatings can protect only accessible surfaces. This fact is often neglected in design. Appropriate distances required for tools in corrosion protection work must be respected, as well as minimum dimensions of openings for access to confined areas, minimum dimensions for narrow spaces between surfaces, and the incorporation of design features that may be used to avoid deposits accumulating or water being trapped.

For offshore structures, the steel surface should be free from welding spatters and slags, pores, undercuts, and laminations. The surface also needs to be dressed to remove irregular and sharp-edged profiles. Poor weld seam design will cause steel to corrode quickly.

The workmanship of the applicator is also very important. Half of all premature corrosion protection failures are application-related, which means that frequent quality control checks are required. Correct surface preparation and coating thickness are the most important application parameters.

Because offshore structures present some of the toughest corrosion protection challenges for coating systems, the best possible equipment and set up should always be used for the painting job. Automatic blast facilities should be used to minimize variations in surface cleanliness and surface roughness. Painting booths with climate control and temperature regulation are recommended. Two-component spray equipment should be used to minimize mixing errors, and qualified people should be hired for the job.

Today more than ever, the market for corrosion protection of steel wind towers is marked by strong competition. The demand increases for fast-dry, solvent-free coatings, lower thicknesses, and fewer coats. In reality, successful testing and certificates for coating systems does not necessarily guarantee the successful coating performance. Indeed, it is one thing to apply the very best coating under laboratory conditions onto perfectly prepared test panels and submit the panels to laboratory testing. Replicating the same results on site, on thousands of square meters of steel, applied around the clock and sometimes under less than optimal conditions, is a completely different matter.

Anders Voldsgaard Clausen is group wind power segment manager at Hempel A/S. He can be reached at +45 4527 3461. For more information, visit www.hempel.com.

Avoid getting caught up in the minutiae. Success in supply chain management depends on how well you adhere to these seven fundamental laws.

LOGISTICS AND SUPPLY CHAIN management often comes down to how well you execute the fundamentals. No magic here; just the ability to out-execute your completion. I have boiled down these fundamentals into seven laws. How well you adhere to these laws will go a long way in determining how successful your supply chain will be for your company. The seven laws are: Demand, Paradox, Metrics, People, Variability, Optimization and Contingency.

LAW OF DEMAND

It's really all about the demand. Why call it supply chain management? What drives the supply chain ultimately is demand. The issue is how independent and dependent demand affects a company's operations. The more a company refines their knowledge and control of demand management, the more efficient and responsive the supply chain.

LAW OF PARADOX

This is dealing with finite supply chain resources. Here is the paradox: Is your company's supply chain model based on operational efficiency or customer service responsiveness? Companies often struggle with constraints one type of model imposes versus the others. Supply chain cost savings can often affect customer service, while have resources (inventory and capacity) available for responsiveness add cost. Which one do you chose in a business environment of finite resources?

LAW OF METRICS

What gets measured gets done. Does your company have the right mix of supply chain metrics? Do metrics communicate direction and change? Is there too many which can incur paralysis through analysis? A company needs to define what is important to measure for its current economic environment and review and modify periodically.

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. Well trained people doing the right job will make you successful. It takes a combination of leaders who I like to say, build the railroads and staff, who run the railroads to be successful. Do you have the right people, making the right decisions at the right time?

LAW OF VARIABILITY

Does it seem like you are on the tail end of crack the whip?

Variability within a supply chain amplifies as a company's product and information move up the supply chain. This issue of variability is the number one reason why supply chains are not more efficient. It needs to be recognized, measured and controlled. Does your company have visibility and control to damper variability?

> "The more a company refines their knowledge and control of demand management, the more efficient and responsive the supply chain."

LAW OF OPTIMIZATION

Are you able to see the forest for 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 reminds me of saying I once heard: "We are going to save money no matter how much it costs." Sub-optimization happens when your supply chain is not viewed in the entirety. Procurement, manufacturing, warehousing, distribution and transportation need to be view as a single entity and not individual parts.

LAW OF CONTINGENCY

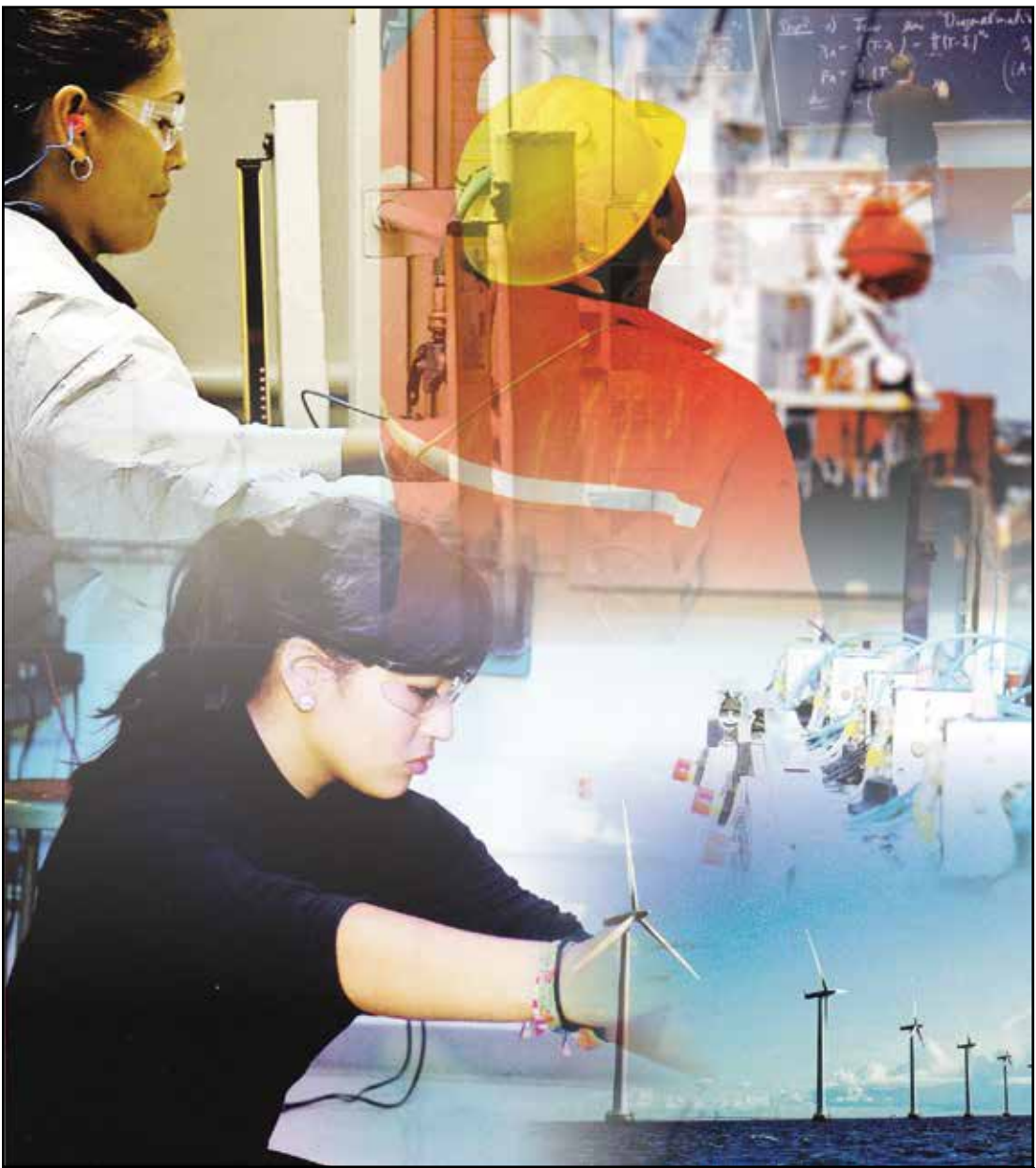
Planning is great, execution is even better, but stuff happens. This law often makes or breaks a company's supply chain. How well a company plans, prepares and anticipate events turns an average company into world class. Does your company have supply chain contingencies developed before they are needed?

I suggest a company take some time to review where they are at with all seven laws. It is a great exercise that will contribute benefit to your supply chain.

Michael E. Graska is senior manager of operations and engineering for Vectora Transportation LLC. For more information, go to www.vectoratransportation.com.

RIO SOUTH TEXAS ECONOMIC COUNCIL

By Stephen Sisk



Regional economic marketing group seeks to capitalize on recent wind energy development to expand industry's presence in southern Texas

DOES THE LONGSTANDING ADAGE "everything's bigger in Texas" hold water? Ask a resident or workforce member of the Rio South Texas region, and they'd likely respond to the affirmative. But there's a chance that instead, they might take it a step further.

Population is up. Industry is up. Skilled workforce numbers are up. Quality of life indicies are up. Retail sales are up. Higher education opportunities are plentiful.

In short, everything's getting bigger in Rio.

In 2008, communities within the four-county (Hidalgo, Starr, Willacy, and Cameron) Rio South Texas region recognized the need to pool their economic development efforts into a centralized organization. The resulting agency—Rio South Texas Economic Council—provides economic development support through combined secondary marketing efforts. The council serves as a quasi-marketing arm for its more than twenty public and private members, with the goal "to attract capital investment and jobs to the region and fostering the growth of the economy."

A large portion of the council's effort is spent visiting industrial trade shows. The council will be exhibiting at WINDPOWER 2013 in Chicago on May 5–8 at McCormick Place.

Texas has the most wind energy of any state in the U.S., when considering pure nameplate capacity, at more than 12,000MW. This accounts for a fifth of the nation's total capacity.

In recent history, the Rio South Texas region—which was had previously been anemic in wind energy in comparison with the state—has seen a boom in wind energy.

Earlier this year, Charlotte, N.C.-based Duke Energy announced the completion of the Los Vientos wind farm project, located within the Rio region in Willacy County. The wind farm, announced in August 2011, was originally planned as a 200MW project.

Two months later, the utility announced that was slightly more than doubling the size of the project by adding a second phase to the project. The 402MW generated at Los Vientos is purchased by CPS Energy (first phase) and Austin Energy (second phase).

The total investment by Duke Energy was not available. But a company executive spoke of the economic impact in a January press release that announced the completion of the Los Vientos projects.

"We're proud to be partnering with CPS Energy and Austin Energy to bring renewable energy to this region," Duke Energy Renewables vice president Milton Howard said. "And, we couldn't have done it without the foresight of the leaders, landowners and people of Willacy County. Thanks to them, we were able to bring 600 jobs to the area during construction, and going forward, the Los Vientos projects will continue to boost economic development, support the local school districts, and be a source of dependable tax revenue for years to come."

The Duke projects were preceded by the completion of E.ON Climate & Renewables' 200MW Magic Valley Wind Farm—Willacy County's first wind farm—in August 2012. Similarly, an EC&R executive extolled the economic benefits of wind energy development during an on-site dedication.

"We are honored to be a part of the local community, and we look forward to providing economic support and renewable, homegrown energy for many years to come," said Steve Trenholm , CEO, EC&R North America. "Wind farms create jobs, and provide an economic shot in the arm to farmers, ranchers, and rural communities across America."

The development of two wind energy projects within such a short period of time could indeed prove to be a major boost to the Rio region.

In 2012, Texas also led the nation in terms of new wind energy installations. Developers brought 1,826MW of wind energy online in Texas last year—again, more than any other state. Rio's Duke and EC&R projects, totaling 602MW, accounted for nearly a third of all Texas' new wind installations last year.

Rio South Texas Economic Council members hope to turn those numbers into a trend.

Council members met with representatives from Duke and EC&R, as well as personnel from Seimens and Vestas (who were chosen as turbine suppliers for the two Willacy projects), during the WINDPOWER event in Atlanta in 2012.

Those existing projects may assist the Rio council in attracting further wind energy investment to the region as they continue their efforts at the upcoming WINDPOWER 2013 event next month in Chicago.

Located on the southernmost tip of Texas, Rio South Texas is the third largest market in Texas, and the 23rd largest market in the United States. The region also boasts the distinction of being the largest U.S./Mexico border region in the nation.

Regional population has increased more than 29 percent since 2000, according to U.S. Census numbers; and by 2015, the population is expected to show a nearly 40 percent increase over 2000 tallies. In 2010, there were more than 1.2 million residents in the region. That number nearly doubles when taking into account the number of residents living in bordering communities in Mexico.

For more information, visit www.riosouthtexas.com.

LARGE WIND TURBINE BLADE TRANSPORTATION SOLUTION: THE AEROSCRAFT

Unique airship with 66-ton payload capacity provides an efficient, ecological alternative means of component transportation.

By Sadia Ashraf

Sadia Ashraf is the communications manager at Worldwide Aeros Corp. For more information about the Aeroscraft, visit www.aeroscraft.com or call 323-201-8383. Visit Aeroscraft at WINDPOWER 2013 Booth 2321.

THE WIND BUSINESS IS ULTIMATELY a logistics business. Worldwide Aeros Corp. (Aeros), a Southern California-based international aircraft company, is proposing that its logistics product, the Aeroscraft, will provide wind power components manufacturer a more cost efficient solution for delivering current turbine products, as well as larger scale turbine components, from production to delivery site.

Aeros is a lighter-than-air (FAA-certified) aircraft manufacturing company that does in-house research, development, production, flight and operation of its advanced-technology tethered aircrafts and air vehicles. For the past 25 years, Aeros airships have been used globally for government, commercial and humanitarian applications. Aeros products include the non-rigid FAA type certified Aeros 40D Sky Dragon airships, advanced tethered aerostatic systems and the new type rigid, variable buoyancy air vehicle—the Aeroscraft.

Motivated to become an international provider of advanced transportation solutions, Aeros developed the Aeroscraft that has the ability to carry a large payload of 66 tons to provide a hi-tech aviation vertical solution to moving heavy and oversized cargo, from point-of-origin to point-of-need, even to areas with limited or no infrastructure.

The Aeroscraft is a rigid variable buoyancy airship—a first of its kind—designed to control airlift in all stages of air or ground operations, including the ability to offload its payload without re-ballasting. The Aeroscraft is not a blimp, zeppelin or a hybrid vehicle. It is a new type of aircraft that combines a suite of new aviation technologies.

OBSTACLES TO WIND TURBINE TRANSPORTATION

"The current transportation infrastructure allows the wind industry to expand rapidly," stated Igor Pasternak, CEO of Aeros, "yet the industry is facing significant transportation problems, which if left unaddressed, will create obstacles to achieving the wind energy industry's full potential."

The U.S. wind industry now totals 60,007MW of cumulative wind capacity (and more than 45,100 turbines) through the end of December 2012. The U.S. wind industry has added over 35 percent of all new generating capacity over the past five years, second only to natural gas, and more than nuclear and coal combined, according to the American Wind Energy Association.

The expansion of the wind energy industry has contributed to transportation and logistics issues confronting manufacturers and developers. Moving wind turbine components from the factory floor to the project site is the main challenge of wind industries. It involves handling sensitive and valuable components that can weigh several tons and be well over a hundred feet in length.

As larger-scale blades and bigger turbines are developed—beyond 80 ft in length ranging up to 145 ft—utilizing trucks or helicopters to transport these blades in austere or landlocked territories becomes complex. Blade lengths will continue to grow in the future, particularly for offshore wind projects. The largest blades are over 200 feet long (60 meters-plus) for a 5MW turbine. In this situation, the Aeroscraft with its vertical takeoff and landing capability offers a solution to transporting blades from a manufacturing site directly to the point-of-need-destination.

Moving wind blades from the factory floor to the project site poses another major issue. A single turbine can require up to eight hauls through multiple transportation modes: road, rail, and water. Pasternak believes that "utilizing a vertical solution like the airlift capacity of the Aeroscraft bypasses choke points and uneven or even non-existent infrastructure."

For environmentally conscious companies, the Aeroscraft is as ecological (in that it uses much less fuel) as it is efficient, offering a virtually noiseless and no-pollution operation. Not only will it be able to haul massive amounts of cargo, it will do so with quiet, electric engines.

CAN A VERTICAL SOLUTION BE THE ANSWER?

"It's a new era for logistics in cargo. Transportation is our first aim for the Aeroscraft," said Fred Edworthy the Vice President of Aeros. 'It's impossible to get into some of the resource rich areas of the world. Areas of the far north or the Amazon are examples." He explained that the Aeroscraft's rigid aeroshell and internal ballast control system provides its distinctive use of off-board ballasting, as well as off and on-loading capacity while hovering that can truly benefit the transportation of wind turbines.

Pasternak, who is also the engineer behind the Aeroscraft, said that it can potentially overcome several wind blade transportation limitations. Traditionally, airships and blimps have provided a broad range of services which include surveillance, advertising, broadcasting and communication missions. However, they have considerable limitations in transporting cargo because they require ballast to keep them grounded once cargo is offloaded.

Moreover, they have a non-rigid structure which is prone to puncture. Another obstacle conventional and hybrid airships face is the inability to control buoyancy. The requirement for ballast exchange, ground infrastructure and need for runways significantly limits the usefulness of the vehicles for cargo applications.

"The Aeroscraft can address the transportation challenges of the increasing size of wind turbine systems," Pasternak said. This aircraft will be able to, vertically and internally in its cargo area, transport large-scale, 10MW-plus wind blades and other components to any destination in the world. Pasternak maintains that the Aeroscraft's fuel efficiency and ability to circumvent all manner of obstacles make it an economical and viable solution to wind turbine transportation.

THE AEROSCRAFT PROTOTYPE'S TECHNOLOGIES

The Aeroscraft is unique because of its Internal Ballast Control system, allowing it to offload

cargo without ballast. The Aeroscraft can control lift at all stages with its Vertical Takeoff & Landing (VTOL) means, and can carry maximum payload in hover-mode. It is also built with rigid, carbon composite shell, making it sturdier and better able to carry payloads. The Aeroscraft needs no hangar facility, airport or excessive maintenance.

The first version of the Aeroscraft recently reached completion. Funding and oversight of the Aeroscraft Project has been supported by the Defense Advanced Research Projects Agency (DARPA), the U.S. Defense Department Defiance's Rapid Reaction Technology Office, and the National Aeronautics and Space Administration (NASA).

The massive 260-foot length prototype Aeroscraft (a subscale of the planned 66 ton ML866 model) was built to prove its scalability—was designed by the LTA (Lighter than air) and aeronautical engineers. Recently in a series of controlled tests, the Aeroscraft vehicle has demonstrated its ability to operate without land infrastructure and ground crew, interfacing with remote as well as with onboard cockpit controls.

The prototype also demonstrated the control of static heaviness, or COSH, a system that allows direct management of the vehicle's buoyancy. When the airship is on the ground, this system pumps helium into helium pressurization envelopes.

Ambient air will fill portions of the internal structure of the airship and the vehicle will become heavier than air. This allows it to the offload of cargo without having to onload ballast (weight) to keep the airship on the ground. The COSH system will release the helium from the pressurization envelopes in preparation for flight, allowing the vehicle to become lighter than air and enabling vertical takeoff, Pasternak explained.

Austere terrain and isolated environments remain reachable only in the developed transportation periphery. Reaching places from Western Alaska to rural India demands a vertical airlift solution with the ability to bypass infrastructure. The Aeroscraft could be the future airlift freight solution for wind turbine transportation with its key features:

- Vertical Takeoff and Landing (VTOL) capability that allows operation without ground infrastructure and from unimproved landing sites.
- Advanced Buoyancy and Low Speed Control System that enables aerial loading and offloading without external ballast.
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length limitations in wind turbine transportation.

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WIND TURBINES AND THE AEROSCRAFT

The most common turbines being installed at wind farms produce about 2.5MW of electricity and have 164-foot-long blades. At that length, it is difficult to erect them because the pieces often cannot fit on rail cars or highways, if there even are any roads to the farms. Sometimes, special roads have to be built to bring turbines to the site.

Wind turbine design and engineering has progressed to build ever-larger turbine units. The industry has demonstrated that building one larger turbine (7MW-plus) is more economical than building multiple smaller systems (2MW-plus) with an equivalent total power output.

Edworthy suggests the Aeroscraft can limit the construction of roads and ports saving time, resources and the environment and "lowering transportation and logistics costs that will reduce the overall cost of wind energy." Its internal payload compartment is capable of accommodating multiple blades over 300 feet long, and it can be customized to overcome the growing height, weight, width, and length limitations in wind turbine transportation.

According to AWEA, the fourth quarter of 2012 saw 8,380MW of wind power capacity installed, bringing total 2012 installations to 13,124 MW, which equated to over

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Figure 1 Case Study: High Altitude Wind Farm (10,000 Acers – Steen's Mountain in Oregon).

5,000 turbines, resulting in approximately 40,000 transportation hauls.

A single turbine can require up to eight hauls (one nacelle, one hub, three blades and three tower sections). For an entire project of 150MW, transportation requirements have been as much as 689 truckloads, 140 railcars, and eight ships to the United States. And, many projects today are much larger than 150MW (the largest operating project in the U.S. is currently 736MW, and projects of more than 4,000MW are in the early stages of development).

The major transportation challenges for wind turbines include trucking with overhead objects, height requirements, and weight limits; varying state and local regulatory system under which the trucking industry operates; limited carrier capacity and non-optimized loads and scheduling. Train transport is lacking due to dimension limitations; and lack of access to final project sites. Water and shipping transportation is limited to as there is no access to final delivery sites. The Aeroscraft can gain direct access to remote areas and eliminate costly intermodal challenges.

Taking one of the high-altitude wind farms, Oregon Steen's Mountain, as an example, Figure 1

Figure 2: Aerial Loading & Unloading.

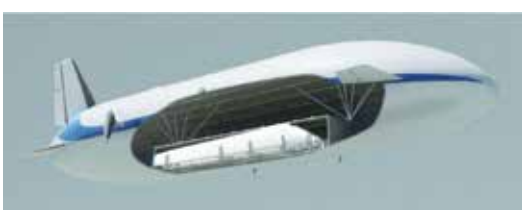

Figure 3: Internal Compartment with Restraint system.

illustrates the logistics challenges the current transportation industry is facing and the technological advancement of the vertical airlift of the Aeroscraft.

The Aeroscraft vehicle can also prevent blade damage that is caused sometimes during the current intermodal transportation. Aeros has proposed a customized cargo vehicle for the wind industry with an internal compartment design that accommodates multiple blades over 400-plus feet long and other turbine components. The compartment would be comprised of:

- Rear Cargo Bay Entrance/Exit that allows for convenient ground loading/offloading and maintenance access.
- Payload Cradle Platform with restraint system that provides stability and protects against a combination of static, dynamic, and stochastic loads.
- Base Hatch and Tension Wire System, along with the vehicle internal buoyancy and low-speed control system, that enables aerial loading/offloading, turbine installation and maintenance.

Before takeoff, blades and other payload would be loaded by its rear cargo bay entrance and secured by the restraining system on the cradle platform. The Aeroscraft could takes off vertically and during the whole flight, the equipped active attitude control system keeps the platform level to minimize the strain and damage (Figure 2). At arrival, the Aeroscraft can ascend vertically, open the base hatch, extend the tension wire, and unload the payload (Figure 3). It can also work as a crane to assist installation and maintenance.

The company is currently in discussions with leading companies in the wind turbine industry who are seeking to streamline logistics for the transport of large components that cannot be transported intact across normal highway or air corridors. The Aeroscraft heavy-airlift air vehicle can potentially change the way wind turbines are transported, offering a viable vertical solution.

Aircraft experts and several U.S. agencies are betting that the Aeroscraft vehicle with its advanced technology capacities can transform the transportation of large and heavy cargos, supporting and altering any number of the world's equipment-dependent mega-projects and the industries that manage them – including wind energy, aerospace, petroleum, highway construction, engineering and telecommunications.

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MANAGING DRIVETRAIN HEALTH: KNOWLEDGE IS POWER, TIME IS MONEY

Stretching your O&M budget can be achieved by properly and systematically processing the data derived from condition monitoring equipment.

By Larry Jacobs

Larry Jacobs is the marketing and sales manager, North America, for Romax Technology. He can be reached at 802.858.9185 or larry.jacobs@romaxtech.com. Visit Romax at WINDPOWER 2013, Booth 2909.

AS THE U.S. WIND INDUSTRY transitions to a larger install base of turbines that are either out of warranty or soon to be, the focus of every owner/operator turns to optimizing their operations and maintenance and more specifically, managing the health of the drivetrain and its components. The cost of failures as it relates to drivetrain components can quickly erode an O&M budget—especially if these failures were not anticipated or if they occur within a timeframe that was not expected. Drivetrain health management is the key to understanding the existing condition of drivetrain components as it provides effective failure mode prediction (not just fault detection) and it allows for well-timed planning of maintenance activities.

The English philosopher Sir Francis Bacon has been credited with the phrase, "knowledge is power". This is never more appropriate when it comes to drivetrain health management and failure mode prediction. This knowledge comes from two sources—the knowledge that a health management system provides to the end user and even more importantly, the knowledge, expertise, and experience that went into developing such a system. There is a ton of data that can be generated by health management systems such as condition monitoring, lubrication sampling, oil particle counters,

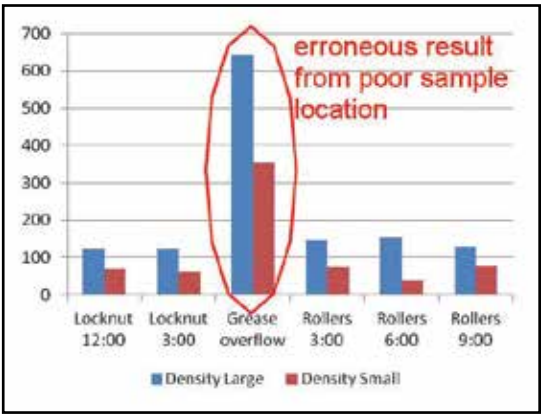

Figure 1: Particle counts for main bearing grease samples: Samples are compared for six locations (taken the same day). Sampling from the grease overflow trap (common practice) provides erroneous results.

FEATURES OF INSIGHT IDS SOFTWARE

Vibration Monitoring
Temperature Monitoring
Lubrication Sample Monitoring
Particle Counter Monitoring
Component Inspection Database
Failure Database
Reliability Analysis
CMMS Integration
Monitoring Hardware Independence

Table 1: Features of InSight iDS software.

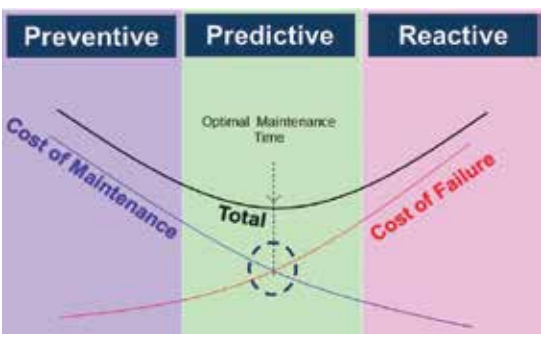

Figure 2: Optimal maintenance time.

SCADA, etc., but the true value of these systems lies with the processing and analysis of this data. Romax InSight software combines all these various health management tools into one system (Table 1) and InSight services provides the engineering know-how to implement processes, re-engineer components or develop retrofit modifications to reduce failures. Grease sampling is a common monitoring technique for large bearings, and Romax InSight iDS software provides tools to trend grease ferrography and elemental composition results; yet as shown in Figure 1, without implementation of proper sampling procedures the monitoring can be erroneous. This result is included in procedures developed for technicians to illustrate why to sample a certain way.

The "Maintenance Scheduling" sidebar (p. 39) shows the progression of main bearing failure where the specialized analysis implemented within the InSight software provides at least six months prediction on failure. Having this knowledge well in advance of the pending failure is equally important to managing drivetrain health. Figure 2 looks at the optimal time to perform maintenance as it relates

	Technique	Advantage	Disadvantage	Cost
1	Temperature analysis	Inexpensive	Temperature in load zone higher than measurement point. Often warning is very short.	$
2	Grease analysis	Can offer early detection	Adds 30-60 minutes to maintenance	$$
3	Portable vibration	Cost effective in the short term. Can combine with gearbox and generator sweep	Trending requires multiple turbine visits. Over the long term fixed installation is better.	$$$
4	Visual inspection	Conclusive if conducted properly	4+ hours of machine downtime. Covers are heavy, safety issue. Grease disposal.	$$$$

Figure 3: Drivetrain health management options in lieu of permanent vibration monitoring installations.

to three maintenance models. The preventive model results in high cost of maintenance with low cost of failure. Reactive maintenance results in a low cost of maintenance with high cost of failure. The intersection of these two modes is predictive maintenance and is determined to be the optimal maintenance time. However, it should be noted that this optimal time is not necessarily a one-size-fits-all model. Having the information of a failure mode (knowledge is power) well in advance of the pending fault (time is money) puts the owner/operator in the driver's seat for scheduling the maintenance activity and allows for well-informed decisions. It provides flexibility on when to order parts, resource availability, and when to deploy a crane (if needed); and these may not always align with the "optimal" maintenance time.

So, when we say "optimizing O&M" what do we really mean? It means optimizing production—ensuring turbines are available when the wind is blowing and ensuring turbines are operating at peak performance. It also means minimizing operational costs through balancing cost of maintenance with cost of failure (as shown in Figure 2). When we take these into consideration with the understanding that time is money, then the objectives for any maintenance related activity is to schedule during low wind seasons (ideally), and when labor and equipment is available, and at most reasonable cost.

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FAILURE CAUSE ANALYSIS

A Romax engineer disassembles planetary stage of a gearbox during failure root cause analysis.

An important step to developing solutions for costly machinery problems at wind farms is conducting a step-by-step root cause analysis of failures. With a thorough understanding of the failure modes and the early indicators of failure, solutions can then be developed to either mitigate the failure or reduce the severity and frequency.

Typical activities include:

- Uptower inspections – investigating the failure issue in-situ
- Factory teardown – step by step disassembly, inspection and photographing of each and every part in the failed component. Review of all the evidence by experts
- Metallurgical analysis – examining steel hardness, microstructure compositions, failure mechanisms and material quality
- Engineering simulation – assessing functional behaviour and loads and stresses versus allowable limits
- Design review – review by experienced engineers in areas such a lubrication, assembly, tolerancing and design for manufacturing

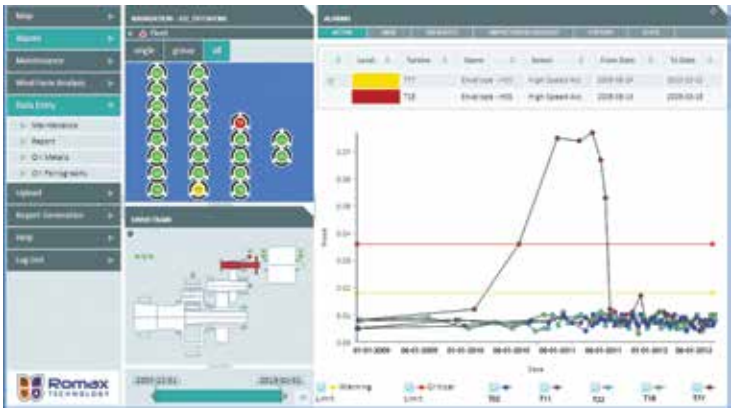


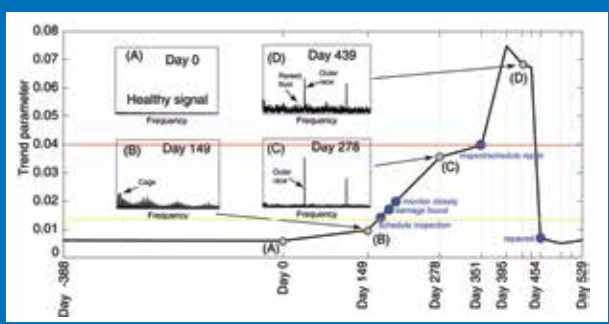
Figure 4: Screenshot of InSight iDS health monitoring ool.

Field experience is important in developing effective and reliable analysis tools (See "Failure Cause Analysis," p. 38). Root cause analysis and field inspections of drivetrain failures provide important feedback in validating analysis techniques. We all want to find the needle in a haystack so practical experience is just as valuable. With drivetrain health management there are many factors to consider when determining the best solutions—size of the wind farm, size and age of the turbines, installed condition monitoring hardware, and component failure rates. These are all considerations in determining what's best. Ideally, a well-established continuous monitoring program is in place and a historical database is being established. But in cases where CMS hardware is not yet installed what are my options? As an example, Figure 3 outlines some tools and techniques to consider when establishing a drivetrain health management program for main bearing failures.

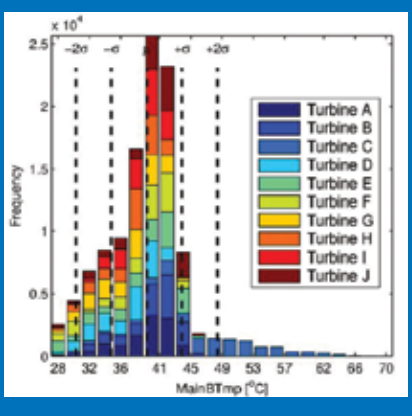
When it comes to reducing risk with knowledge and time, and turbine O&M cost savings, the long-term benefits of a health management program are clearly measureable—prevent catastrophic events, convert downtower repair/replacement into an uptower repair, effectively manage spare parts inventory, curtail operations for prolonged production, mitigate insurance risks, and amortize equipment costs.

MAINTENANCE SCHEDULING

Vibration based condition monitoring aids with scheduled maintenance planning. Given that for most wind farms, unscheduled maintenance makes up a significant portion of operation costs, better planning enables cost savings to justify the cost of installing vibration based condition monitoring. This is especially the case for failures where the repair requires removal of the aero-rotor and a crane to be deployed. There may be many days of downtime if the crane cannot be mobilized immediately. Lead time on large components such as main bearings and gearboxes can also bring delay and add to the costs of the failure. Main bearing failures are a common issue where vibration based condition monitoring is an effective tool for maintenance planning. The macropitting damage can be detected months in advance, compared with temperature analysis, which can detect damage only days, or at most a few weeks, before a machine shutdown is required. In this representative example, the damage is detected almost one year before the turbine faulted from over-temperature. Vibration analysis reveals the damage component, in this case, the outer race. The statistical temperature analysis shows Turbine C is operating at a significantly higher temperature, but the temperature rise is only evident at the final stages of damage.



Temperature monitoring shows main bearing on Turbine C running hotter than fleet. Failure indication was two weeks prior to turbine shutdown.



Vibration condition monitoring typically provides more than six months' notice for planning main bearing replacement.

MAKING SENSE OF THE CMS MARKET

Six key steps to take into account when swimming the sea of condition monitoring purchase decision-making.

By Brogan Morton

Brogan Morton is the product manager for TurbinePhD, a product of NRG Systems. He can be reached at bpm@nrgsystems.com. For more information, visit www.nrgsystems.com. Visit NRG Systems at WINDPOWER 2013 Booth 2032.

CONDITION MONITORING FRAMEWORK

The recent acceptance of the value of condition monitoring in the wind industry is driven by two major factors: First, turbines coming off warranty are exposing owners to the true operations and maintenance costs of the wind farm; Also, major component failures are driving excessive maintenance costs. To combat these challenges, owners and operators are deploying condition monitoring systems (CMS) to detect faults early, before they cause secondary damage. Catching faults early means the cost of repair can be reduced, resulting in significant savings.

With the acceptance of condition monitoring systems on the rise, there is a related increase in the number of vendors bringing CMS products to market. Almost every turbine OEM offers a CMS, and gearbox and bearings suppliers are readily joining this increasingly crowded market. Furthering the complexity of choosing a condition monitoring system is the fact that several different technologies are available (e.g. vibration, oil debris, SCADA). Deciding which system or technology provides the highest value can feel like comparing apples to oranges.

Unfortunately, there is no performance standard or benchmark to compare the various condition monitoring systems. A prospective buyer is charged with the difficult task of determining which CMS

will provide the right performance and the right price. To assist in this decision-making process, it is important to focus on the over-arching goal of a condition monitoring system—providing the user with recommendations that allow them to make optimal O&M decisions.

With this goal in mind, it is important to understand the process through which a CMS converts a physical measurement (e.g. vibration, oil debris, temperature, pressure) into a recommendation for action. Luckily for prospective buyers, there is a generic process that all condition monitoring systems follow. This process is comprised of six steps:

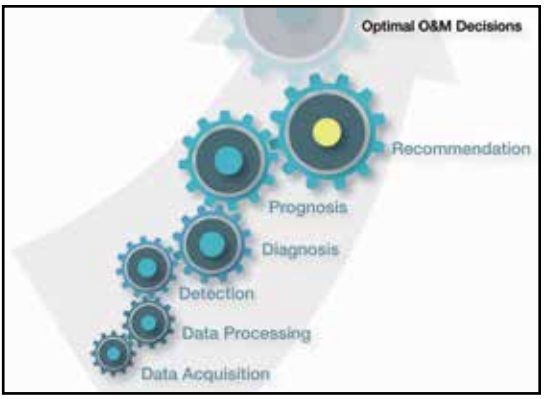


Figure 1: The six steps of an effective condition monitoring process.

- Data acquisition – translation of a physical phenomenon into an analog measurement that can be converted into digital format.
- Data processing – processing the digitized sensor measurements into meaningful indications of component health.
- Detection – classification of whether the condition indicators are "normal" or "abnormal."
- Diagnosis – validation of the fault and a determination of its location and severity.
- Prognosis – estimation of how much longer the faulted component will last before it needs to be replaced.
- Recommendation – determination of what maintenance action is necessary and when it should be performed

Figure 1 shows this condition monitoring framework in a graphical format. Understanding how a particular condition monitoring system performs each of these steps will give a prospective buyer a much clearer understanding of the system's capability and the cost of each step in the process.

The process moves from data acquisition to recommendation in a linear fashion. Since the output of each step drives the next, the quality of work done in one will affect downstream performance, so considering the CMS from a holistic systems level is most appropriate. It is also worth noting that the condition monitoring process stops at recommendation. It is up to the operator to use those recommendations to make better operations and maintenance decisions.

There are many different types of wind turbine condition monitoring systems with very different methods of providing turbine health information. Instead of using one of these technologies as an example, we will use an even more generic example that everyone can recognize; a visit with your physician.

DATA ACQUISITION

Every CMS starts with a sensor that translates a physical phenomenon into an analog measurement, which is then converted into digital format for further

processing. In our example, a doctor will take a blood pressure measurement as a routine part of the visit. The data acquisition sensors in this case are the stethoscope used to measure cardiac cycles, and the pressure cuff used to measure arterial pressure. The digitization of the sensor outputs is performed by the ears (stethoscope) and eyes (pressure cuff) of the doctor.

The stethoscope and pressure cuff needed for a blood pressure measurement are not high-precision sensors. This is very different than wind turbine condition monitoring systems where the fidelity of these measurements will affect the down-stream processing, so understanding the sensitivity, bandwidth and accuracy of the sensor chosen is important. It is also important to understand if a CMS can determine component health on all of the fault modes that can effect it. Oil debris systems can detect pitting failures but cannot detect cracking faults. Vibration-based systems can detect both pitting and cracking, but most cannot determine the health of components in the planetary section. Prospective buyers should take an inventory of the components on their wind turbines that have been driving the largest maintenance costs and determine their most common fault modes.

DATA PROCESSING

After the sensor measurement has been converted to a digital format, the CMS must process the sensor measurements into meaningful indications of component health. In our physician example, the data processing step requires combining the data from the cardiac cycle (stethoscope output) with the pressure variations (pressure cuff output) measured at the same time. The physician must then average all the pressure variations over the course of the measurement. The complexity of the two measurement signals is reduced to two simple numbers, 120/80mmHg for example, which characterizes the patient's current blood pressure.

The data processing step involves two distinct sub-steps. The first is to isolate the relevant portion of the measurement signal from the 'noise' and involves some sort of filtering of the original signal. In our example, the physician only looks at the pressure levels during specific parts of the cardiac cycle, filtering out the rest of the extraneous values. When the signal isolation is done well, it will increase the sensitivity of the CMS, allowing for easier discrimination between "un-faulted" and "faulted" components. It will also reduce the inevitable variation in these component condition indicators

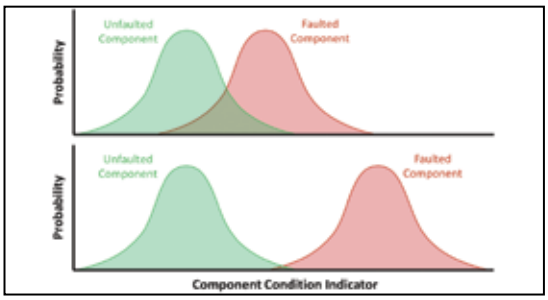


Figure 2: Effective data processing is the difference between poor fault discrimination (top) and good fault discrimination (bottom) .

due to the complex environments and varied conditions in which wind turbines operate.

The second step of data processing is extracting the salient features of the filtered signal that provide an indication of component condition. The resultant condition indicators should ideally identify the presence of different fault modes in the component. For example, a gear can have several fault modes including root cracks, surface pitting or misalignment. Each of these fault modes manifests itself in different ways, so no single condition indicators will accurately characterize all of these faults. Therefore, several condition indicators based on different filtering methods should be used to identify potential fault modes in each component.

The goal is to design data processing that calculates condition indicators that identify all potential fault modes and easily discriminate between faulted and un-faulted components. Figure 2 shows two different scenarios—a condition indicator that results from poor data processing (top), and a condition indicator that result from effective data processing. In both of the graphs, the green distribution is the range of the condition indicator typical for an un-faulted component while the red distribution is the range of the condition indicator typical for a faulted component. In the top graph, there is a great deal of overlap between the two distributions due to inadequate data processing, so the ability to discriminate between a faulted and un-faulted component is poor. In the bottom graph the effective data processing has provided adequate separation of the faulted and un-faulted condition, so discriminating between the two is straightforward.

DETECTION

Once the measured signals have been turned into condition indicators, the CMS must classify whether the condition indicators are "normal" or "abnormal". This is achieved by comparing the current condition indicator to a reference range, which can be either a statistical baseline or model-based. In our example, the physician has determined the patient's blood pressure, but that measurement itself is not instructive. It is not

until that measurement is compared to the commonly used 120/80mmHg threshold that we can determine if it is high or not.

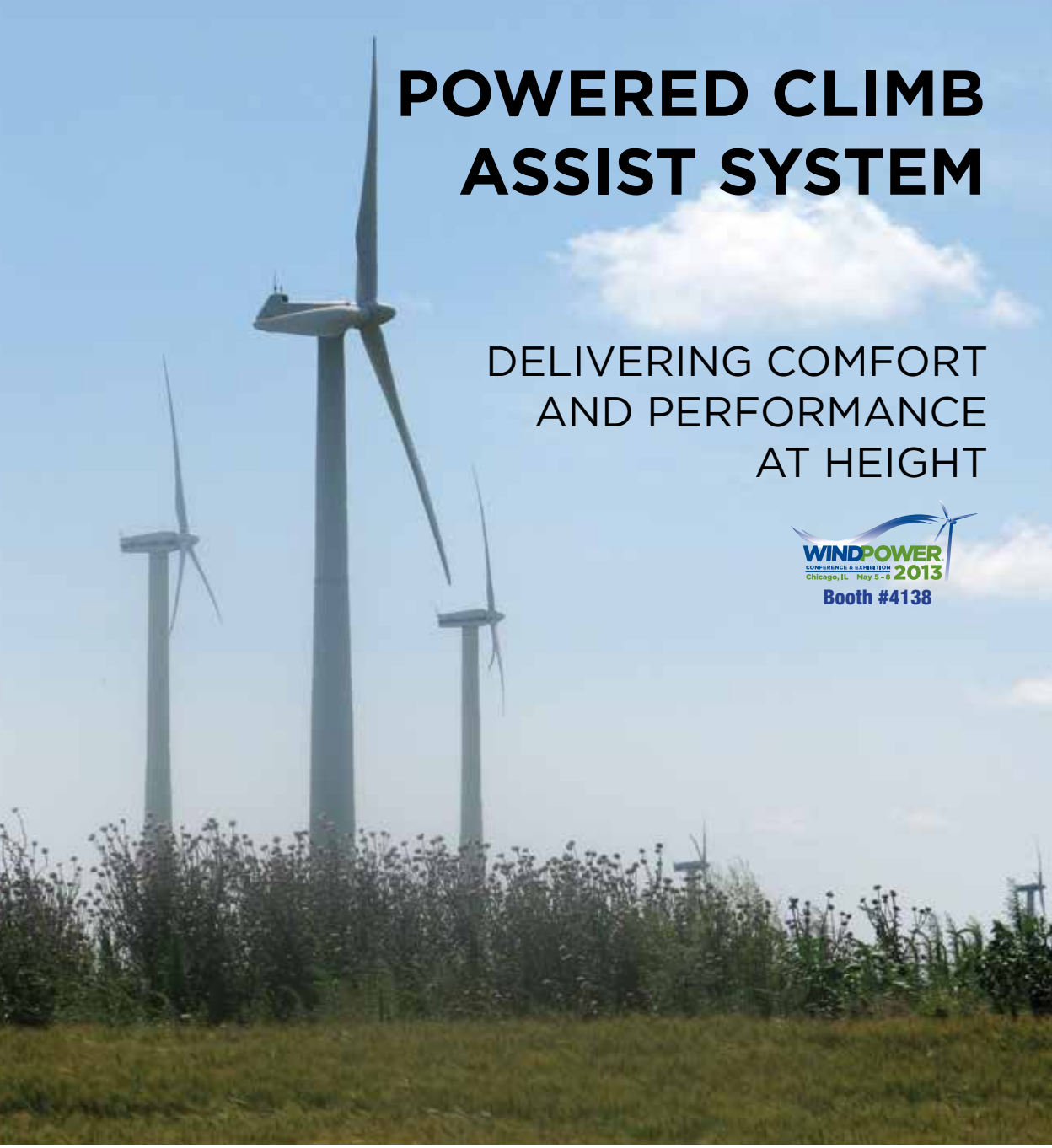
Setting the level of the threshold used to classify the condition indicators as either "normal" or "abnormal" is the crux of the detection step. The threshold is typically a high limit set on a condition indicator. In our example, the blood pressure threshold is based on studies including large populations of patients with no known hypertension. For wind turbine condition monitoring it is much more difficult due to complexity of the systems and the number of different turbine makes and models in the field. Figure 3 shows the un-faulted (green curve) and faulted (red curve) component distributions as before, but a fault threshold has been added. In this case the un-faulted and faulted distributions have significant overlap, so misclassifications are inevitable.

In the figure, the threshold was set to balance possible missed detections and false alarms. In practice, setting thresholds is even more difficult because there are few (if any) measurements of what a faulted component looks like. In the best case, CMS thresholds are set based on knowing what an un-faulted component looks like (green distribution in the graph) and a predefined probability of false alarms. Because of the inherent complexity and direct impact threshold setting has on performance, understanding how a condition monitoring provider will set thresholds is one of the critical questions to ask when selecting a system. Experience shows that systems that use a poor process for setting thresholds are more prone to false alarms that drive unnecessary maintenance.

DIAGNOSIS

Now that one of the condition indicators detects a faulted component, the CMS must validate the fault and determine its location and severity. The validation is done by examining the context in which the indication was high. The condition monitoring system can compare the current condition indicator to the historic value of the same condition indicator and under what operating condition it occurred. If this is the first high value and it happened under high transient loading, it may be best to ignore this indication until more evidence is gathered.

Continuing our example, if a patient had a high blood pressure reading a physician may be inclined to diagnose hypertension. Yet upon further discussion it was discovered that the patient had a stressful week. In addition, the patient has no family history of hypertension and their historic



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blood pressure values were lower. Given this context a physician would not diagnose hypertension, even though high blood pressure was detected during this single visit. Now imagine if the patient did have a family history of hypertension and their historic blood pressure values had been trending upward for several years. In this context, the diagnosis would be hypertension and the next step would be to determine the severity.

Just like in the physician example, determining the severity of a turbine fault is a critical part of a CMS diagnosis. The action needed for a component with a small fault and months of remaining useful life left is very different then the action needed for a severely faulted component with only hours left.

PROGNOSIS

Once the fault has been validated and the severity is known, the next piece of information needed is an estimate of how much longer that component will last before it needs to be replaced—also known as the remaining useful life. The remaining useful life of the component can be estimated in several ways but requires knowledge of two things—the current severity of the fault,and an estimate of the future operating conditions of the component. Using our example, once the severity of the patient's condition is understood, the physician can determine how it will degrade. If the current hypertension is low (fault severity) and the patient already lives a healthy lifestyle (future operating conditions), the prognosis may be that the hypertension will have little impact on the patient's future well-being. If the hypertension is currently low but the patient lives a sedentary, unhealthy lifestyle, the prognosis may be that if the hypertension is left untreated it will lead to heart disease in five years. Both situations started at the same severity level, but the anticipated future conditions led to vastly different prognoses.

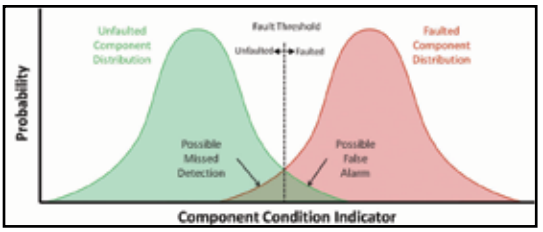

Figure 3: The threshold level and how it is chosen is critical to system performance.

A prognosis for a wind turbine CMS is used slightly differently. Instead of changing future operating conditions to prevent component failure, an estimate of operating conditions is used to determine when the component will reach the end of its useful life. Figure 4 show a graphical example of the projection of future component health. The amount of time between the current time and the time the estimated trajectory of the component's future health (blue dotted line) crosses a predefined threshold (red line) defines the remaining useful life of the component.

RECOMMENDATION

Once the condition monitoring system has an estimate of fault severity and a remaining useful life of the component, the necessary maintenance action and when it should be performed can now be determined. The recommendation step is really an aggregation step; information is taken from the diagnosis and prognosis steps and combined them into a clear recommendation of what to do next. In our example, if the patient is diagnosed with mild hypertension and the prognosis is that there will be no impact on their overall health, the recommendation would be to maintain their current lifestyle. If the patient receives the same diagnosis but the prognosis is that the mild hypertension will lead to heart disease in five years, the recommendation would be to exercise more and change to a healthier diet.

For wind turbines the recommendation will come in the form of a maintenance action that will be required. If a bearing is faulted the recommendation could be to verify the fault through visual inspection within the next month and schedule a replacement of the bearing within three months. This recommendation would allow an operator to plan maintenance outages ahead of time, reducing downtime and lost revenue.

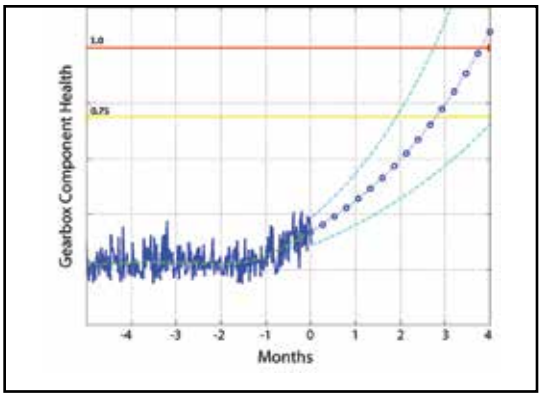

Figure 4: An estimate of remaining useful life for a component is created by projecting the current health forward using a model of component health and the operating condition it is most likely to see.

CLOSING THOUGHTS

The framework of the condition monitoring process presented here should provide a guideline for prospective buyers when considering a condition monitoring system purchase. Many systems available do not cover the entire condition monitoring process. This may require an operator to interpret a significant amount of data, so be sure to ask vendors what parts of the process their systems cover and if additional services are required to get to a recommendation. In the end, the efficacy of a condition monitoring system is only as good as its ability to provide operators with information that can be used to drive better operations and maintenance decisions.

BREAKING THE 34.5kV "STANDARD"

Drawing on hydro experience, Acciona extols use of 12kV collection system to lower energy costs through elimination of step-up transformers.

By Scott Baron and Jon Saxon

Scott Baron is director of global marketing and Jon Saxon is global commercial manager for Acciona North America. For more information, visit www.acciona.com. Visit Acciona at WINDPOWER 2013 Booth 1553.

IN WIND FARM PROJECT DESIGN, the principle objective is to attain the lowest levelized cost of energy (LCOE). Several key variables contribute to this goal such as selecting the optimal wind turbine generator (WTG) for the site, positioning the WTGs to maximize production given available land, minimizing electrical losses, and designing the most cost-effective Balance of Plant (BOP). But one variable that can lower the levelized cost of energy is often overlooked: the collection system voltage.

The most commonly used collection system voltage for North American wind farms is 34.5kV. While this voltage has become the "standard" in the industry, it is not necessarily the best option for wind farms that are considering wind turbines that produce electricity at a medium voltage. Choosing the right wind turbine and optimizing the collection system design in conjunction with that wind turbine voltage could make the difference between a profitable project and an unprofitable project.

Acciona has extensive experience designing and building 12kV collection systems on the wind projects that it owns and operates worldwide, which is possible due to the unique 12kV electrical voltage of the wind turbine generator associated with the Acciona Windpower technology. Based on this experience and

history, the benefits of a 12kV collection system are further described.

HISTORY OF THE 12KV SYSTEM

Fifteen years ago, after establishing itself as an early leader in the development and ownership of utility scale wind farms in Spain, Acciona began designing and producing an in-house WTG technology to supply both its own and third-parties' projects. Because Acciona's WTG was engineered from the unique perspective of an owner/operator with vast experience owning and maintaining fleets of turbines from various other manufacturers, the design integrated several key improvements on what was, and is, available in the market. One key aspect of this design, and one that remains unique in the global WTG market to this day, is a generator voltage of 12kV.

Having experience with small hydroelectric power plants with 12kV generation that had operated successfully in some cases for over 50 years, Acciona decided the same proven technology could be applied to wind turbines. The principle motivator was to reduce LCOE. For many projects globally, a 12kV collection system that can avoid intermediate step-up transformers at the wind turbine is the best solution. Since the inception of the Acciona Windpower technology, the company's turbines have been installed on 12kV collection systems at over 40 projects globally, yielding technical and financial benefits for numerous project owners. The rest of the projects have used traditional step-up transformers such as 20kV, 30kV, or 34.5kV in cases where those voltages were determined to be optimal.

BENEFITS OF A 12KV SYSTEM

The main benefit of using a 12 kV collection system (in conjunction with 12kV electrical generation from the WTG) is the reduction in BOP costs. The overall BOP cost of a 12kV collection system is usually lower than a 34.5kV system for at least two reasons. First, step-up transformers at the wind turbine (typically padmounted or in the WTG nacelle) would not be required since the electricity from the wind turbine is being directly injected into the collection system at 12kV. Second, 12kV collection system cable is less expensive per linear foot.

In addition to the above and also contributing significantly to the overall value of a 12kV system, the absence of step-up transformers allows for the realization of a stronger power curve (i.e. more energy production at a given wind speed) due to avoidance of electrical losses associated with the transformation of power from one voltage to another. This increase in energy production can be estimated between 1–1.5 percent, which is significant given that it occurs over the 20-plus year life of the wind farm. Figure 1 illustrates the comparison of a 12kV

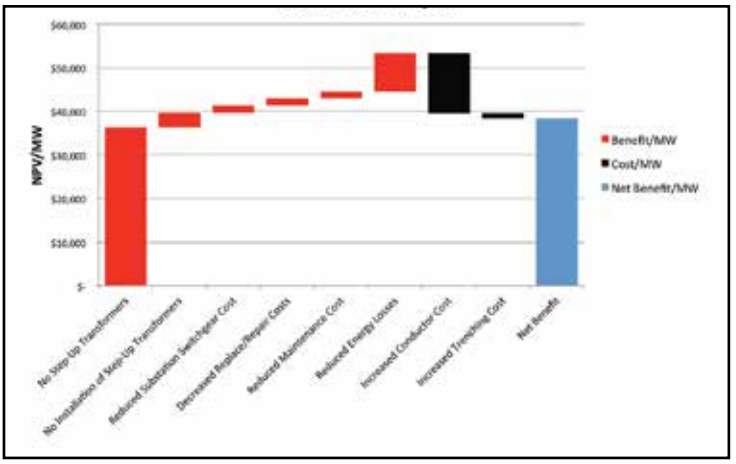

Figure 1: Example of NPV benefit of 12kV vs. 34.5KV collection system at 61.5MW wind project.

and 34.5kV collection system for a typical 61.5MW project, where the benefits are shown on a net present value (NPV) basis. In the example shown, the net NPV benefit of about $40,000/MW represents a savings of roughly $2.5 million, which can translate into $2–3/MWh lower LCOE. This is significant, especially for smaller-medium size projects where every dollar counts.

A 12kV collection system would also typically provide better reactive power capabilities than the traditional design, since WTG step-up transformers consume reactive power generated by the WTGs. In some cases, this reduction in reactive power performance would necessitate additional reactive power compensation in the substation, either through static means or, if dynamic features are necessary, with the installation of a STATCOM, increasing the BOP costs as well as the ongoing maintenance cost of the wind farm.

Cost savings on this system are also seen over the life of the project through reduced O&M costs. This includes savings due to avoided maintenance and replacement of WTG step-up transformers—maintenance that could also detract from the turbine availability. Wind farms leveraging this 12kV collection system will also see a dramatic reduction in the number of terminations and connections on the collection system. In instances where these critical terminations fail, there would be associated downtime until the issue is fixed.

HOW TO KNOW IF A 12KV SYSTEM IS RIGHT FOR YOUR PROJECT

A 12kV collection system (in conjunction with 12kV electrical generation from the WTG) can be the best choice for a number of different wind power project scenarios. However, it is typically the optimal solution for medium sized utility-scale projects where the furthest WTG is within three miles (five km) from the substation. If a project is smaller than 75MW, there is a high likelihood that the project's economics can be improved by using a 12kV collection system. According to data produced by the American Wind Energy Association (AWEA), over the past five years approximately 35 percent of utility-scale wind farms installed in the U.S. are smaller than 75MW, yet the vast majority of these are utilizing 34.5kV collection systems (in conjunction with wind turbines that generate at 690V). This may have been the optimal solution with regard to other wind turbines, but if these projects would have installed a medium voltage wind turbine such as the 12kV Acciona Windpower technology, perhaps millions of dollars could have been

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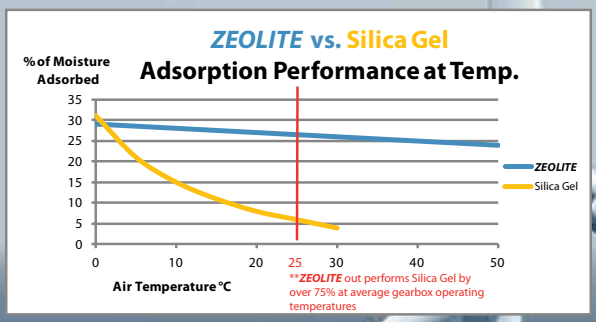

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Examples over 3 years based on $75,000 Wind Turbine Technician salary and 2 Technicians required per turbine for changing out a desiccant Breather. Silica gel breathers are replaced every 6 months. ZEOZORB breathers are replaced every 12 months.

Scenario 1 - Silica Gel Breather		Scenario 2 - ***ZEOZORB*** ZZ-300 Breather	
Average Silica Gel Breather Cost	**= $150**	***ZEOZORB*** ZZ-300 Breather Cost	**= $75**
Average Silica Gel Breather Life	**= 6 Months**	***ZEOZORB*** ZZ-300 Breather Life	**= 12 Months**
Average Wind Technician Labor Rate	**= $40 hr**	Average Wind Technician Labor Rate	**= $40 hr**
Number of Technicians Required	**= 2**	Number of Technicians Required	**= 2**
Number of Breather Change Outs Per Year	**= 2**	Number of Breather Change Outs Per Year	**= 1**
($150 x 50) + ($40 x 2 Tech x 2 Hrs x 2 Change x 50)	**= $23,500**	($75 x 50) + ($40 x 2 Tech x 2 Hrs x 1 Change x 50)	**= $11,750**
Total 3 Year O&M Cost	**= $70,500**	Total 3 Year O&M Cost	**= $35,250**
		Total Savings **$70,500 - $35,250**	**= $35,250**

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A wind farm is designed to maximize energy output with the lowest cost possible. However, there is typically a trade-off between the WTG layout that would maximize energy output and the layout that would minimize the MW installed cost. This is typically affected by the location of the designated interconnection point for the wind farm, which in most cases determines the location for the wind farm substation. Other factors can also affect the wind farm design such as constraints related to the complexity of the wind farm terrain, environmental or archaeological restrictions, proximity to cities or villages, and landowners and related permits.

All of these topics should be considered during the earliest stages of development for any wind farm project since these decisions can have a significant impact on the benefits that can be extracted from a 12kV collection system.

As previously described, there is a fairly quick rule of thumb to determine whether a 12kV collection system would be more economical than a higher voltage alternative. It is based on measuring the distance from the farthest WTG to the wind farm substation. Simply draw a circumference with a radius of three miles (five5 kilometers) around the substation, and check if more the 95 percent of WTGs are within that boundary. If that's the case, the 12kV collection system option will typically be the optimal solution. For those cases that do not meet this criterion, one should still perform an analysis since cases have been known where 12kV is still the best option when this distance is around six or seven kilometers. This criterion is valid for any size wind turbine (e.g. 1.5MW or 3MW).

REAL EXAMPLES OF 12KV SYSTEMS

As previously mentioned, Acciona Windpower turbines have leveraged the 12kV collection system on over 40 projects globally, yielding technical and financial benefits for numerous project owners.

The best way to examine the benefits of a 12kV collection system is to explain real examples of wind farms where the technology has been installed and to analyze the overall NPV benefits. Three examples are presented below, where a complete economic and technical assessment was performed. The economic benefits are particularly sensitive to certain variables such as the energy price, cost for the electrical equipment, and the layout of the project, making the 12kV collection system option more or less compelling depending on each case. Therefore, it is recommended that each project is analyzed to determine the potential economic benefits of a 12kV collection system.

YEONG YANG (SOUTH KOREA) – 49.5MW

This 49.5MW wind farm is located in South Korea and entered operation

in 2009. There are 33, 1.5MW wind turbine generators operating at 60Hz frequency. All turbines are within the ideal range from the substation (i.e. less than five kilometers, or three miles).

Two different options were considered while designing this wind farm—12kV and 30kV. An optimal collection system design for each option was developed. The key variables considered were cable costs, trenching costs, substation switchgear costs, and WTG step-up transformer costs. For each case, the capitalization cost of electrical losses due to both cables and transformers over a 20-year time frame was considered. Electrical losses were also calculated based on the expected annual energy production of the wind farm.

To provide a basis for comparison between the two options, a baseline of 100 percent can be considered for the cost of the 12kV option, which includes cables, trenching and capitalization of losses. The cost of the 30kV option can then compared to this base level. In summary, the cable and trenching costs are lower for the 30kV option than the 12kV option; however, these costs are more than offset by the transformer capital costs and capitalization of electrical losses, resulting in a cost premium of 28 percent for the 30kV option. This economic assessment, combined with the technical benefits described above, provided the justification for a 12kV collection system at this site.

LAMEQUE (CANADA) – 45MW

This 45MW wind farm is located on the Atlantic coast in New Brunswick, Canada and entered operation in March, 2011. There are 30, 1.5MW units operating at 60Hz frequency. All turbines are within the ideal range from the substation (i.e. less than five kilometers, or three miles).

Following the same criteria as Yeong Yang, a study was completed comparing the advantages of the 12kV collection system over the 34.5kV collection system for the Lameque wind farm project. However, the case for a 12kV collection system is even more compelling in this case because the alternative option introduced a cost increment of 46 percent.

In contrast to the Yeong Yang project discussed above, the capitalized electrical losses for the 12kV collection system for this project were actually higher than those for the 34.5kV collection system. However, overall there was still a clear economic advantage for the 12kV model. Therefore, the cost of WTG step-up transformers and switchgear more than offset the higher electrical losses seen in the 12kV model. Furthermore, this case was corroborated for other voltage scenarios to ensure that the 12kV model was optimal.

WAUBRA (AUSTRALIA) – 192MW

This 192MW wind farm is located in Australia and entered into operation in 2009. There are 128, 1.5MW units operating at 50Hz frequency. Due to the large number of machines, the approach was to divide the wind farm into several sections and route the power through five mini-substations. All of these mini-substations operate at 12kV and step-up to 66kV for overhead transmission to the 220kV interconnect substation. Therefore, unlike the other cases, the solution proposed here also includes transformers from 12–to 66kV with a rated power of 50MW each. The distance from the furthest turbine to its corresponding substation is less than five kilometers. Furthermore, this solution demonstrated that the 12kV collection system can be leveraged in unique environments to yield additional project value.

The cost assessment performed for the Waubra project showed that while the electrical losses are higher in the 12kV collection system, this is more than offset by the significant reduction in capital costs. Overall, the 12kV collection system provides NPV savings around 10 percent, highlighting that the 12kV collection system can add value in diverse environments.

ACCIONA 12kV OPTIONS

Acciona Windpower is the only wind turbine OEM that has designed turbines to generate at 12kV, but medium voltage wind turbines may become more common (other OEMs have announced future products that will use between 6–12kV voltage). The Acciona Windpower Product Line includes the AW1500, 1.5MW wind turbine generator using an 82-, 77-, or 70-meter rotor diameter and the AW3000, 3.0MW wind turbine generator using a 125-, 116-, 109-, or 100-meter rotor diameter. Acciona offers each of its wind turbine generator models at multiple tower heights with both concrete and steel options that vary by rotor diameter selected.

In addition to the 12kV collection system, Acciona Windpower's global fleet of WTGs have recorded 98 percent availability and a failure rate of less than 1 percent on major components across its installed global fleet of more than 3,900MW in 13 countries.

CONCLUSION

When designing the layout of a wind farm and modeling its financial and technical performance, don't assume that the "standard" 34.5kV collection system is the only or most economically sound option. In many cases it is not, especially when there is an opportunity to install a medium voltage wind turbine. Once a preliminary layout for the substation and the WTGs has been defined, an analysis regarding the optimal collection system voltage should be performed. This analysis takes a holistic approach, taking into consideration all economic aspects of the project such as cost of the wind turbines, electrical losses, transformer costs, and maintenance costs over the project's 20-year life. A wind farm developed with either the AW1500 or AW3000 and with a layout where all WTGs are within a radius of five kilometers (about three miles) from the substation presents the opportunity to improve energy production and reduce the overall BOP cost by utilizing a 12kV collection system.

When this criterion is not possible to achieve, there is still potential to achieve significant savings using the 12kV collection system, as seen in the example of Waubra, highlighted above.

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CROSS-TECHNOLOGY DRIVETRAIN LUBRICATION

Choosing the proper lubricant is essential to turbine maintenance, whether using gearbox or direct drive technology.

By Daryl Luke

Daryl Luke is a global product manager with Castrol Industrial. He can be reached at x. For more information on Castrol Industrial, visit www.castrol.com/industrial. Visit Castrol at WINDPOWER 2013 Booth 4548

WIND POWER CONTINUES TO GROW despite the global economic turndown and predictions are that wind power can meet 8 percent of the world's electricity consumption—compared to 2.26 percent today.

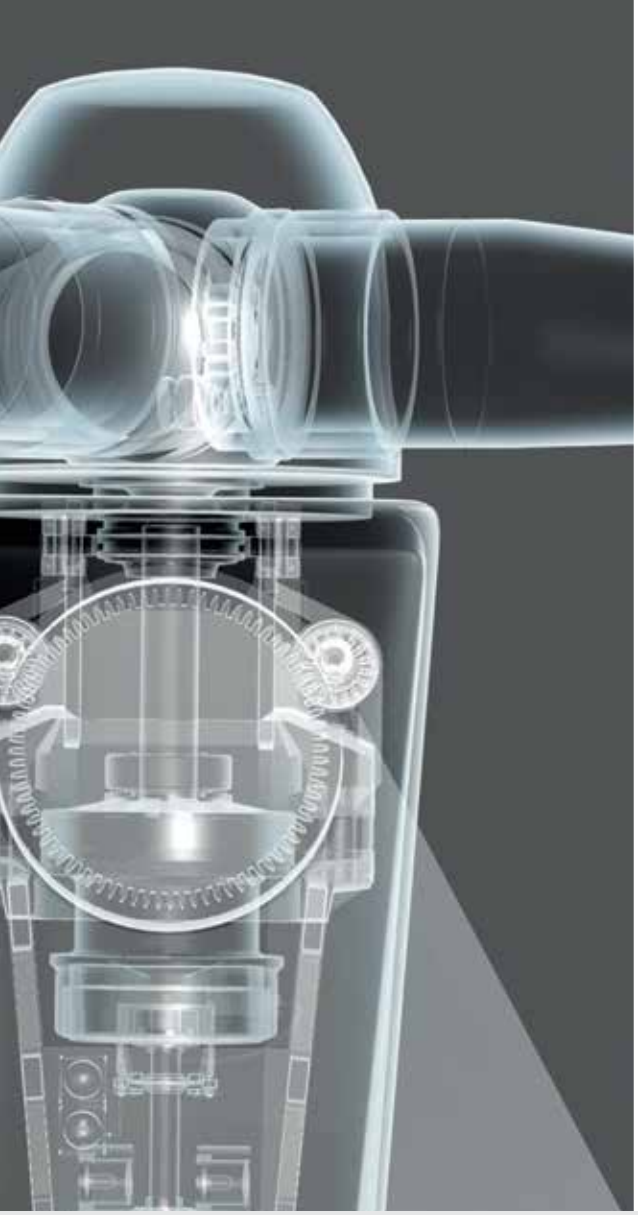
Growth rates will slow in coming years compared to the end of the previous decade, but these are still well above industrial norms.

Offshore wind turbine installations also will increase over the next few years, as turbine manufacturers and operators minimize the land environmental impact.

This growth is good news for suppliers to the wind industry such as lubricant manufacturers. However, with this growth technological advances in wind turbine designs and the increasing search for locations with higher wind speeds—including offshore options—mean that turbine manufacturers must constantly keep pace, which in turn is placing more stress on the lubricants used.

TYPES OF WIND TURBINES—DIRECT DRIVE VS. GEARBOXES

Essentially in wind turbines there are two main ways of transmitting power from the blades into electricity—through either a gearbox system or a



direct drive system (some systems have both, often called "hybrid systems"). The former being oil-lubricated and the latter normally grease-lubricated.

Opinions vary on which type of system is the more favorable considering the inconsistency of information in the public domain. However, gearbox turbines provide the majority of systems (approximately 79 percent) currently commissioned and in service, although the proportion of direct drive systems is expected to increase in the near future.

Direct drive turbine useage has grown from around 18 percent in 2006 to 21 percent in 2011; and this is expected to climb to 29 percent by 2020, with wind turbine manufacturers such as Siemens and GE shifting from gearbox turbines to permanent magnet direct drive turbines [1].

As gearbox turbines continue to dominant the wind market focus in this article is given to those systems.

GEARBOX DRIVEN WIND TURBINES

With the relatively high stress on wind turbines (e.g. high wind conditions and emergency stops), the right choice of lubricant is crucial to the smooth running of gearboxes and the overall performance of turbines. Indeed, investing in the right lubrication could help to save a typical operator managing 50 wind turbines up to $250,000 year-on-year.

To identify the right lubricant, operators need to initially understand what can go wrong with the gearboxes. While it is true that the causes behind many failures are the way the gear meshes and bearings are aligned, the choice of lubrication can have a major impact of failure rates.

MICROPITTING

Micropitting is surface fatigue that can result in micro-cracking and the formation of minute micropits which can sometimes give a metal surface a frosted or grey appearance. In some instances, micropitting can cause whole gear teeth to break off.

Although micropitting accurately describes the appearance and mechanism of the problem, it is sometimes also referred to as fatigue scoring, flecking, frosting, glazing, grey staining, microspalling, peeling, and superficial spalling.

This condition occurs under mixed-film elastohydrodynamic lubrication (EHL)—where oil film thickness is of the same order as surface roughness average, and where load is borne by surface asperities and lubricant. In addition to contact stress due to normal loading, sliding between gear teeth causes tractional forces that subject asperities to shear stresses.

Micropitting is complex, unpredictable and difficult to control, despite extensive research on the problem. That said, there are ways to help prevent it happening in the first place. Engineers should maximize lambda (using a thicker film to coat the gear teeth and prevent them from touching), optimize gear geometry, optimize metallurgy, optimize lubricant properties, and protect surfaces during running-in.

Testing of different lubricants can actually show how micropitting can progress with inferior lubricants. Figure 1 shows how lubricants can performance under speed and load, giving rise to potential catastrophic pitting.

BEARING FAILURE

Bearings are among the most important components,

but are often very fine and can damage easily. In particular, the bearings which support the shaft that holds gear teeth in place have very fine tolerances and can be damaged by even small particles.

The potential causes for bearing damage are numerous. For example, working beyond the original design specifications, speed, load, and temperature could all change due to the varying requirements of a site. Also, careless handling and seals that are too tight can cause insufficient bearing clearance while inadequate or unsuitable lubrication can also cause failure.

Damage can be split into two categories. In the first instance, primary damage occurs. Signs of primary damage include: wear, indentations, smearing, surface distress, corrosion, and electric current damage .

Primary damage can then lead to more serious secondary damage, including flaking and cracks—which can ultimately cause equipment failure. Even at the primary damage stage, bearings may have to be scrapped because they are causing excessive internal clearance, vibration and noise. Most failed bearings show signs of both primary and secondary damage. Another issue that can shorten bearing life is the impact of wear particles from the gear box,such as those emitted from micropitting.

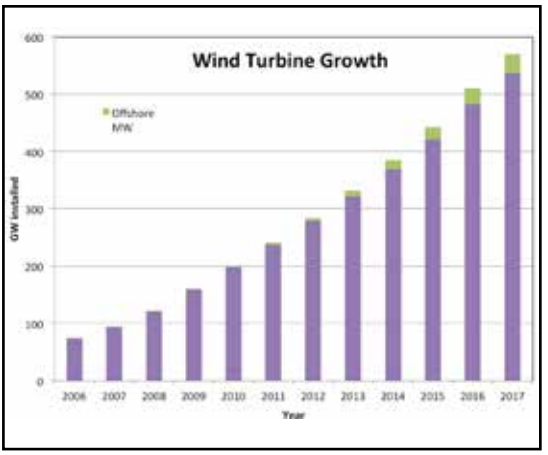


Figure 1: Wind Turbine Growth.

FOAMING

Foaming most likely occurs during periods of high wind, when the turbine is operating at high speed. These higher loads cause severe churning, pushing air into the oil. This means the lubricant doesn't pump or circulate, reducing its effectiveness. Additionally, this can cause oil level fault alarms, which could lead to the turbine being stopped at the most favored time for energy production, and unnecessary climbs for maintenance crews to investigate.

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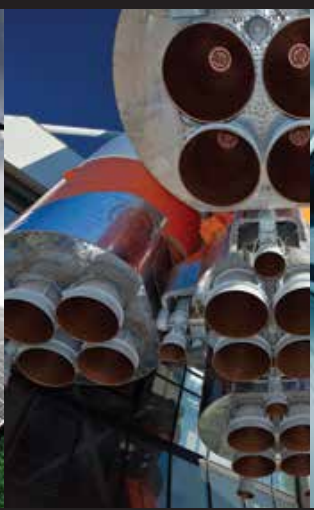

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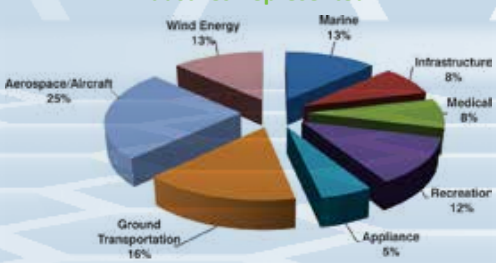

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GEARBOX LUBRICATION

Proper lubrication is one way of helping eliminate many challenges that occur in goth gearbox and overall turbine maintenance. Using an inferior lubricant for turbine maintenance can save money in the short-term, but can cause risky long-term effects. Potential annual cost savings resulting from the switch to an appropriate gear oil is estimated at up to $5,000 per turbine. This takes into account associated reductions in the typical number of oil changes, as well as labor and parts cost savings. If you include potential lost revenue due to turbine downtime and the cost of fully replacing a gear box, the savings could be considerably higher.

DIRECT DRIVE WIND TURBINES

Direct drive systems do not use a gearbox. Rather, they offer slow movement of all the parts of the wind turbine's systems, resulting in reduced wear and tear of the system and superior reliability. Direct drive turbines have been in the wind power market for a long time, but have risen in popularity in recent years due to the issues explained above for gearbox-driven turbines. Direct drive turbines been quoted to be more reliable than gear box systems. However, there are drawbacks to direct drive systems, as explained below.

GLOBAL AVAILABILITY

There are some concerns regarding the global availability of rare earth metals used to make the magnets in direct drive systems. China, which supplies about 95–97 percent of the global demand, introduced export quotas in 2004, and later a 40 percent cut in the quota in 2010, for various reasons such as:

- Environmental considerations – Reports of toxic pollution surrounding rare earth mines.
- Increasing domestic demand – Chinese demand is forecasted to exceed the average global rate of growth.
- Conservation of resources – Aiming to slow the rate of exhaustion of Chinese reserves.
- Encouragement of higher value manufacturing investment - Export taxes and quota restrictions resulting in rare earth products cost up to three times more for firms outside China than domestic ones. This may be intended as an incentive to foreign manufacturers to relocate to China and invest in the Chinese higher-value manufacturing industry.

Alternative sources are expected to become available from the U.S. and Australia by 2014, and are predicted to help meet the anticipated global non-Chinese demand. However, the expected increase in use of electric vehicles (which also

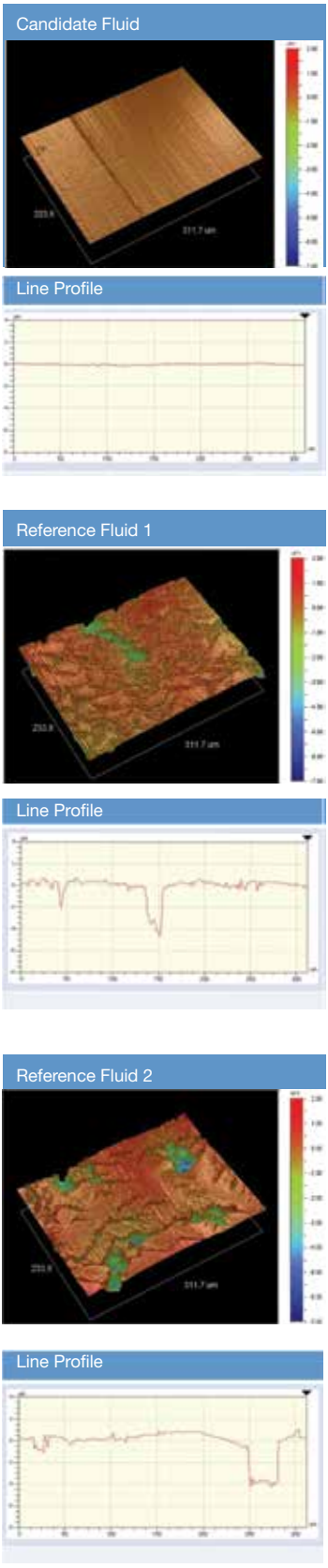

Figure 2: Comparison of 3D Optical Microscopy and Profilometry1/2
Area 3 (=230 x 310 um^2

require rare earth minerals) will likely contribute to an increase in demand.

NOISE GENERATION

The blades on direct drive turbines turn faster and generate more noise on average when compared to gearbox-driven turbines. This can be an issue on land, but is less of an issue for offshore turbines.

INDUSTRY IMAGE

Direct drive systems, given the noise and rare earth ecological aspects, are seen to go against the industry image of socially responsible, sustainable, and environmentally-friendly electricity generation, when compared to gear box technology.

COST AND WEIGHT

In the past, direct drive turbines have been slighted due to higher costs and heavier nacelle weight when compared to gearbox-driven turbines. However, in recent years several turbine manufacturers have been researching emerging direct drive technologies with significant reductions in weight and (until recently) reduced costs.

DIRECT DRIVE LUBRICATION

Lubricant selection is more standardized for gearbox systems than direct drive systems, as industrial gear oils are fairly well specified and can be used in gear boxes produced by varying OEMs. Conversely, the greases used in direct drive systems appear to be less well-defined, leading to a plethora of greases for similar applications and direct drive producers.

HYDRAULIC DRIVE TRAIN

Although the two primary types of wind turbine drive train systems are described above, hydraulic technologies have been introduced in recent years. The advantages of hydraulic drives are:

- Very compact nacelle
- High torque/weight ratio

Disadvantages are:

- Emerging technology has yet to be proven or widely adopted for the wind industry
- Unknown reliability for wind applications
- Asset Earning Power (AEP) unproven

With wind energy continuing to grow, further technological advances like hydraulic drives will likely be introduced. However, the high costs of testing—especially in offshore applications—mean that the speed of introduction could be relatively slow.

CONCLUSION

Whatever system is used, the proper lubrication can help to enhance performance, lifetime, and productivity, as well as reduce downtime. All of this can help to deliver commercial benefits and competitive advantage. With increasing pressure on turbine machinery to work harder and last longer, lubrication remains as important as ever as a key function of wind turbine maintenance.

[1] Global Data. Wind Turbines Go Back to Basics, Nov 28, 2012

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DESIGNING "BRILLIANCE"

General Electric's innovation process and the development of the "World's First Brilliant Wind Turbine"

By Katelyn Buress and Lauren Thirer

Katelyn Buress is in marketing communications, and Lauren Thirer is a product line leader with GE Renewable Energy. For more information, visit www.ge-energy.com/wind. Visit GE Power and Water at WINDPOWER 2013 Booth 2154.

THE DISCUSSION IS HEATED and the room is tense. Healthy discussion and debate go on back-and -forth day after day in the fourth-floor conference room of Vic Abate, vice president of General Electric's renewable energy business. Above the entrance to the room in black writing, a quote from GE founder Thomas Edison: "*I find out what the world needs, then I proceed to invent it.*"

This Schenectady, New York conference room is one of the places where this innovation happens. Another is with GE's engineering teams, based in Greenville, South Carolina, where some of the world's brightest minds in power generation have convened to develop and innovate for the world's future energy demands. For the past 10 years, innovation has been happening at GE's wind business locations across the globe. With 21,000 installed turbines and a global services organization, GE's wind team is home to some of the most experienced in the industry.

With new product launches every few months, this innovation hub churns out new products and technology that keep GE's wind customers at the top of their game. This isn't surprising as GE itself was established on a foundation of innovation that has stayed with the company throughout its 120-plus years.

GE's renewable energy business, goes to work

every day with a purpose —to deliver products and services that move the wind industry forward and make the world a better place. Earlier this year at the European Wind Energy Association trade show in Vienna, Austria, the company launched another one of its innovative products—the 2.5-120 wind turbine. This is the latest model in GE's product line, and is the result of 10 years of dedicated research and development into a single product.

GE bought the wind business from Enron in 2002 and began immediately to improve upon the technology to become the number one OEM in the wind energy industry. The launch of the 2.5-120 is a prime example of GE's ability to provide differentiated technology. The turbine utilizes the latest and most advanced technology from across the company's wind turbine product line, incorporating technology developed in complementary GE businesses, and work performed at GE's global research and development centers. Adjacencies can be seen across GE businesses as experts in rotating machinery collaborate with the aviation, healthcare, and power generation segments.

It is also the world's first "brilliant" wind turbine. Brilliant turbines house powerful applications that integrate advanced algorithms, communications, and energy storage—making intelligent decisions and driving the industrial Internet of wind.

Over the years, GE has invested more than $2 billion in renewable energy technology. Much of that allocation can be seen in the launch of the 2.5-120. Branded the first "brilliant" wind turbine, the 2.5-120 is the world's most efficient, high-output turbine and is the first turbine to manage the variability of wind, providing smooth and predictable renewable power. The turbine does this by using software controls and advanced communications to connect wind farm to wind farm; wind farm to grid; wind turbine to remote operations; turbine to technician; turbine to turbine; and turbine to battery.

Although just recently officially launched in February, the 2.5-120 is part of the company's multi-generational product plan. Ideas to integrate communications technologies evolved and built upon one another as the turbine was under development by GE's global engineering and product management team that works together on new products.

Innovation begins, as Thomas Edison mentioned, by knowing what the world needs. The 2.5-120 was designed to send wind energy where it's never been before. Launching initially in the European market, and later following in the U.S., the turbine provides smart communications and more efficient, high output for low-wind sites. Both Europe and the U.S. have been growing markets for wind energy and pose specific opportunities and challenges for developers. The low wind speeds require large rotors and tall towers, while older, narrower roadways often create logistical obstacles. Throughout most of Europe, wind is economical and there are also rivers and waterways that make traveling and delivering equipment by barge feasible, which made Europe an ideal initial launch region.

Additionally, the goal of making wind power behave more like traditional power generation is always floating about in the wind industry. GE has deep understanding of grid integration challenges due to its long history in the power generation industry. In fact, in the U.S., the Edison Electric Company was one of the initial developers of

much of the American power grid network. GE maintains a holistic approach to power generation and understands how it influences the stability or frequency of the grid. The company recognized a need in developing a plan to make wind power more like traditional power generation. With these challenges at hand, the GE team went about developing the smartest and most advanced turbine to tackle this landscape.

When developing this new unit and surveying the landscape in Europe and the U.S., GE's objectives were clear: The rotor needs to get larger and the tower needs to be taller. Making those objectives become reality was another question. The company has an evolutionary approach to wind turbine development—an approach that has been successful for a decade through numerous product launches. The company looks at its current fleet and assesses components that work best in one model. They then attempt to incorporate those elements into what is working best in another platform.

For example, the team used this approach when they looked across the product line and realized that the doubly fed induction generator (DFIG) used in the 1.X platform was a premier generator in the industry. The team came to the consensus that the generator should be used not just in the 1.X platform, but also in the 2.X turbine line.

In order to enhance the turbine and grow the rotor dimension, the DFIG electrical system was incorporated into the turbine. The new system enabled the use of longer, low-load blades that capture a large amount of energy without overtaxing the machine. The new rotor, combined with a modified gearbox and advanced controls is the chief technological advancement in the 2.5-120 turbine.

Incorporating DFIG technology into wind turbines not only provides higher efficiency and power (due to its larger rotor). The technology allows for a more serviceable turbine for industry technicians who cut their teeth on DFIGs. GE's wind business uses Mark VI* controllers that are the same technology that are used in GE Power & Water's thermal power generation equipment. Wind technicians who previously worked on nuclear machines are able to transition easily into a role in the wind energy industry because the turbines are using the technology with which they are already familiar. Mark VI* is a well-proven software and hardware technology used to control industrial machinery.

Since this technology is a staple across GE's business segments, the company has years of expertise developing complementary technologies for the Mark VI* controller. An enabling technology for many of GE's aftermarket service upgrades, controls software, and anomaly detection capabilities come from the company's years extensive knowledge and experience related to the Mark VI* technology.

Using technologies from existing turbine platforms is not a new idea exclusive to the 2.5-120 development for GE. This synergistic approach among the 1.X and 2.X platforms was used earlier in the development of GE's 1.6-100 wind turbine. The 1.6-100 was developed after the company had success with the hub and blades from the 2.5-100. GE has the goal of ensuring that the two platform teams don't view themselves as two separate entities. Rather, the teams are encouraged to collaborate in an environment where the free flow of ideas and lessons learned benefits both teams and a "best practices"approach is adopted.

The evolution furthered when the company utilized research and technology originally developed for the 1.6-100 platform into the creation of the 2.5-120. GE's 1.6-100 turbines were the first products to

include some of the most advanced loads mitigation technologies. This feature was subsequently incorporated into the 2.5-120. The "brilliance" in the 2.5-120 is made up of a number of technologies that GE provides. Drawing on its vast resources as a large, international organization, GE has unique technology development capabilities. Among these are the expertise of personnel in the thermal

power generation businesses, as well as the central R&D hubs located within the company's numerous research centers. In total, more than 2,000 engineers and scientists—the majority of which hold Ph.D's—work at the company's global research and development centers.

Model-based controls first appeared in the 1.6-100 turbine and were the result of projects conducted at GE's research centers. These systems are now an integral feature of the new 2.5-120. GE Global Research is also working on the extreme event mitigation technologies—which work to reduce potentially harmful excessive loads—for inclusion in the 2.5-120. Traditionally, wind turbines react to extreme loads as they occur. The generator is programmed to run at a certain speed. When that speed is exceeded, the turbine shuts down. This results in harsh, immediate stoppage, which in turn places a heavy load on the equipment. The new extreme event mitigation technology incorporates unique algorithms that detect data signatures in the turbine's operations that could lead to a potential extreme event. Rather than reacting to an event, the turbine predicts it and pitches the blade prior to an "emergency braking" situation. This saves the customer by avoiding lost power, and extends the turbine lifespan by avoiding an extreme loads situation.

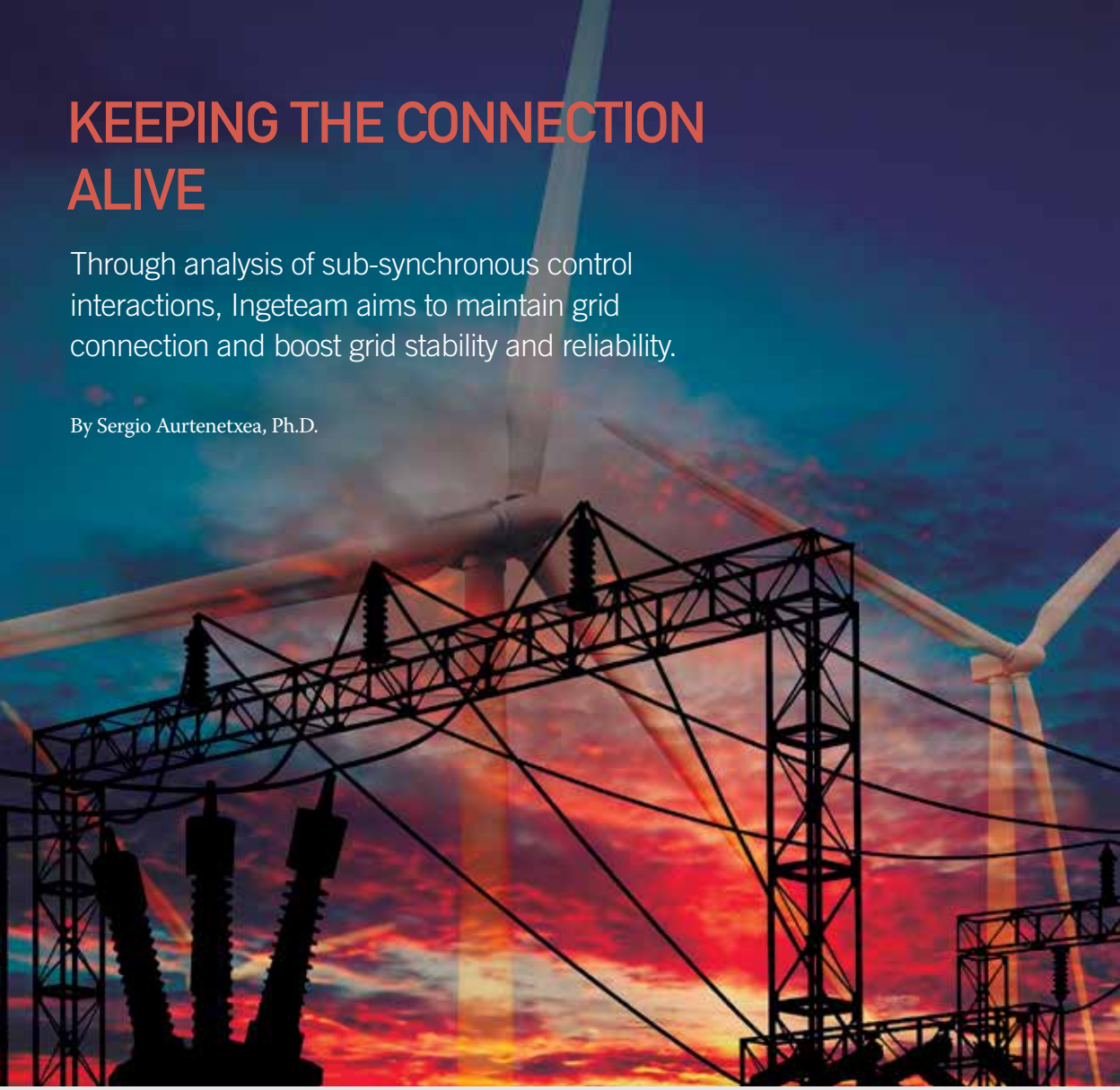
One final way that GE infuses technology into its turbines and drives innovation forward is through the use of data collection and analysis. As turbine technology has advanced, the number of sensors and volume of information those sensors provide has grown. Similarly, the analysis functions performed on that data has expanded. GE has, on average, about 50 sensors on each turbine. Data is collected from about 150 different sources on the turbine. These sensors measure temperature, wind speeds, speed, bending, current, voltage and location and pitch of the blades. Today, data collection capabilities are three- to fivefold what they were a few years ago. GE's turbines collect and analyze 150,000 data points every second to integrate 400MW of wind power into the grid. This information is immediately integrated into turbine operation for smarter servicing and maintenance, and is also used it in the development of future products.The 2.5-120 prototype system is currently underway and is tailor-made for low wind speed sites.

The design of GE's latest wind turbine incorporates the expertise and knowledge developed over years of data collection, power generation expertise, and knowledge of what works and what doesn't in the wind industry. It was designed with the goal of providing a highly efficient, higher-output turbine to the wind energy industry.

KEEPING THE CONNECTION ALIVE

Through analysis of sub-synchronous control interactions, Ingeteam aims to maintain grid connection and boost grid stability and reliability.

By Sergio Aurtenetxea, Ph.D.



Sergio Aurtenetxea, Ph.D. is a R&D engineer in power conversion–wind with Ingeteam Power Technology S.A. He can be reached at sergio.aurtenetxea@ingeteam.com. For more information about, visit www.ingeteam.com Visit Ingeteam at WINDPOWER 2013 Booth 2933.

DURING THE LAST YEARS, WIND POWER integration has been increased around the world. In many cases, wind farms are situated in remote locations without grid adapted infrastructures. Other times they are operating within other complex grid configurations along with dynamic systems (FACTS) for power flow optimization or even, they are simply supporting renewable market strategies in islands. These and other new scenarios make distribution and transmission systems more susceptible to disturbances such as voltage dips, harmonics, frequency variations, and other interactions in general.

The analysis of these power grids becomes a critical task to ensure the stability and reliability of the future power system. Therefore, looking forward on the possible future challenges in the wind systems' integration, Ingeteam is working on the role of the power converters in these grids. The work presented in this article is one of the several analyses carried out in this framework.

Here, a specific phenomenon is discussed; the sub-synchronous control interactions (SSCI). This is a relatively new event that could be considered within the sub-synchronous resonant (SSR) events. These phenomena are characteristic in long-distance transmission grids with series compensated capacitors banks. In a general way, sub-synchronous frequency is related to those frequencies under the nominal frequency (e.g. 60 Hz in North America)

and resonance is usually associated to the tendency of a system to amplify oscillations at some frequencies.

The first time the SSR was recognized in an electric grid was in 1970 in southern Nevada. In that case, a synchronous generator unit became radially connected to a series compensated transmission line. One of the natural oscillation frequencies in the mechanical shaft matched the natural oscillation frequency of the series compensated transmission line, and both systems started exchanging energy. This condition led to an uncontrolled growing of the shaft torque oscillations causing damages in the generation plant. After this first sub-synchronous mechanical torque amplification event, other sub-synchronous resonance phenomena have been analyzed and documented. This way, in the literature can be found sub-synchronous torque iterations (SSR TI), sub-synchronous torque amplifications (SSR TA), and an electrical phenomenon called the induction generator effect (IGE). This last effect is caused by self excitation of the electrical system, in the particular case of induction generators connected power systems with very low natural frequencies. Anyway, most of these events show a common factor where the mechanical part is mainly involved.

A NEW EVENT

The growth of wind power has allowed installing many wind generation systems over the world. As new generation systems, these technologies have been integrating on the existing electric transmission systems, where new challenges have surfaced. After almost 40 years of the first documented SSR event, a new incident took place not so far away from Nevada.

On October 22, 2009, two wind generation systems and a series compensated line in the electric transmission system of Texas experienced a sub-synchronous incident. At 6:04 a.m.,a downed static wire caused a fault on a line and its disconnection. During this disconnection, the wind generation systems were radially connected to a series compensated transmission line.

At this point, sub-synchronous oscillations started becoming greater, affecting both grid voltages and currents. Only 200ms after the disconnection of the faulted line, the wind turbine equipment exceeded its electrical ratings. In fact, the voltage of the transmission system had reached 1.5 per unit value causing damages on wind turbine systems. After this, the voltage continued increasing to around 2 per unit value causing more system damages. Finally, 1.5s after the start of the event, the sub-synchronous oscillation was damped. Summarizing, this event left many of the wind turbines severely damaged. Mainly all of these wind turbines were based on Doubly Fed Induction Generator (DFIG) topologies.

The fast increase on voltage and current during the event discarded the interaction between a mechanical shaft and the series compensated line. The behavior itself suggested that it was caused by an IGE phenomenon.

Nevertheless, it was believed until that day that DFIG wind turbines could not present such effect. Further analysis of the event showed a negative dumping caused by the DFIG wind turbines' control system. This way a new sub-synchronous effect was found, which was named as Sub-Synchronous Control Iteration (SSCI).

SSCI: CASE OF STUDY

Simulation modeling is necessary in order to analyze the SSCI phenomenon in a correct way. In fact, both grid transmission systems and wind turbines involve complex configurations, and their behavior is not trivial. Furthermore, there is not much experience about the operation capacity of grid-connected DFIG wind turbines

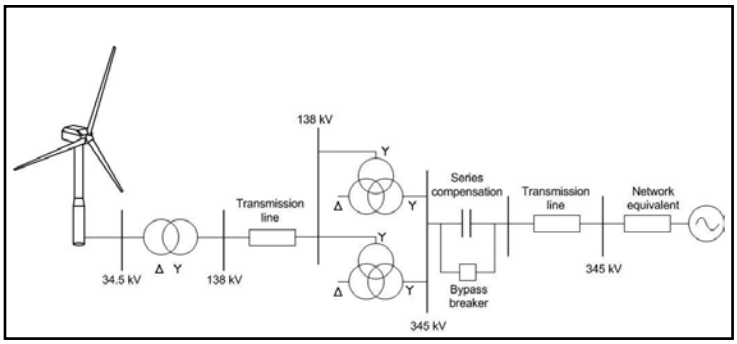


Figure 1: Simplified grid model diagram for SSCI analysis.

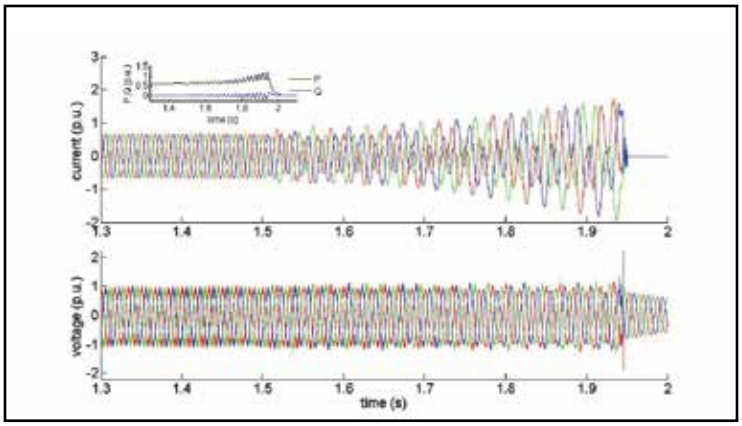


Figure 2: System behavior under a SSCI event with standard control techniques.

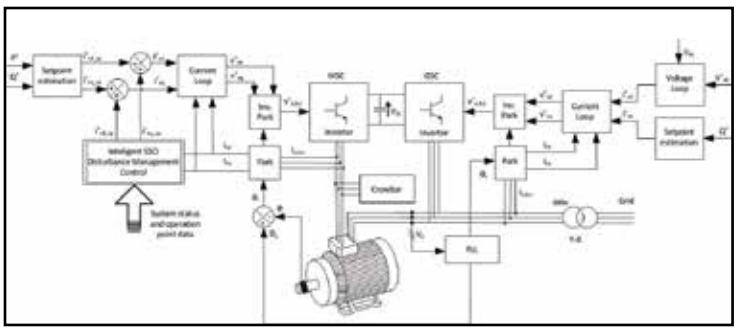


Figure 3: Control model of a DFIG wind Turbine with the SSCI management algorithm.

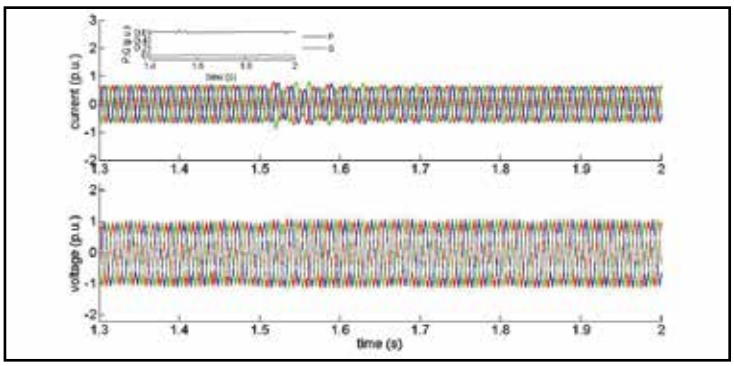


Figure 4: System behavior under a SSCI event with the advanced management control algorithm.

against sub-synchronous oscillations.

Regarding grid configuration, a simplified radial test system was proposed by ERCOT, who operates the electric grid and manages the deregulated market for 75 percent of Texas. Figure 1 shows an approach of the grid model. This model has been adapted and scaled by Ingeteam in order to make it compatible with its simulation tools and wind turbine models. It has allowed testing different operation algorithms from the most standard strategies to the advanced control techniques.

The preliminary analysis performed on this scenario provided some interesting results. On one hand, the series capacitor on the compensated line was the main responsible on the magnitude of the event. Also, the event could occur at almost any operation point of the wind turbine if standard regulation techniques had been implemented.

As regards to the wind turbine and the behavior of its electromagnetic variables during the event, the same sequence was observed in all the cases. When the wind farm became radially connected to a series compensated line, the sub-synchronous oscillations were amplified because of using a standard control in the wind turbines, becoming the whole electrical system instable. In a detailed way, the sub-synchronous oscillations caused by grid breakers operation started interacting with the control strategy of the wind turbines. As a result, the voltage and current oscillations became greater. When the voltage and current oscillations reached a predefined limit, crowbar systems were activated in order to protect the wind turbines. This action made the system even more unstable. Finally, because the grid voltage reached the maximum tolerable limit by the wind turbine, they went to the emergency state where they disconnected from the grid. Figure 2 shows an example the behavior of the voltages and currents under the SSCI event on a DFIG wind turbine. Furthermore, it is possible see the active and reactive power profiles exchanged with the grid.

PROVIDING INTELLIGENCE TO POWER ELECTRONICS

As it has been concluded, the control strategy implemented in the wind turbine has a main role in this event. Different proposals could be considered for SSCI mitigation, from external auxiliary damping devices located in the substation such as STATCOMs or tuned filters to specific control strategies on wind turbines.

Ingeteam is focused on improving the operation of wind turbines in order to intelligently protect against any grid disturbances. This way, the main aim is to provide robustness to the control system on the wind turbine with the capability of being able, not only to stay connected to the grid during this type of events, but also supporting to the grid stability and its reliability.

The improvement against SSCI events could be done in different ways. The first and simplest approach that could be proposed does not involve control architecture changes, only a variation on the control parameters. This solution proposes a change on the gain of the current regulators by increasing the gain of the current controllers on the rotor side converter and decreasing at the same time the gain of the current controllers at the stator side converter. This solution is a good idea as a first approach. However, modifying the gain of the current control loops also modifies the dynamic behavior of the wind turbine. Although with these changes the system can be less susceptible to grid disturbances, the response against some transient events becomes slower and less efficient, especially when the LVRT grid code fulfillment is required. Furthermore, it also could decrease the reliability of the wind system operation in steady state.

Another solution that could be proposed is based on modifying the control architecture of the wind turbines. This second solution proposes the operation of the grid side converter as an active filter. For this purpose, an additional control loop is integrated in the control system. This new loop adds a current demand to the current control loop reference signals in order to compensate the sub-synchronous frequency component. To determine the amount of the compensation added to the current controllers, a control loop based on proportional-integral (PI) controller and a feedback signal of the sub-synchronous current on the stator of the generator is used. The main drawback of this solution is that the grid side converter usually manages the third part of the wind turbine rated power in DFIG type turbines. Therefore, the damping capability of this solution is limited. During the SSCI event, at the wind turbine terminals, the grid side converter will try damping those oscillations while other subsystem with higher rated power composed by, the rotor side converter, the generator and the crowbar system, could be involved on the increase of the sub-synchronous oscillations. Consequently, this solution where two subsystems are working against each other may not be the most efficient solution.

Figure 5: INGECONTM power converter product.

Ingeteam has evaluated these and other operation strategies in a deep way. As a result, it has developed a new technology for power converters in order to provide them the necessary intelligence to mitigate these events. In fact, these new strategies are able to increase the reliability of wind turbines against SSCI and other grid disturbances in an efficient way.

Figure 3 shows a simplified control diagram oriented to SSCI mitigation. In order to facilitate its understanding a standard control technique is presented, which it has been modified with an advanced SSCI management algorithm.

The SSCI management algorithm is added to the current controllers at the rotor side converter because the grid side converter by itself has not the tendency to amplify the sub-synchronous oscillations. Thus, it has the capability to turn the subsystem composed by, the rotor side converter, the generator and the crowbar system on a stable subsystem which helps damping the grid voltages during a SSCI event. Furthermore, this control improvement has the capability to operate continuously adapting it to any grid conditions and damping any sub-synchronous frequency. Figure 4 shows the resulting behavior when a SSCI event occurs and the SSCI management algorithm is operating. As can be seen both the voltages and currents are damped, minimizing the effect of grid disturbance. In fact, the active and reactive power profiles exchanged with the grid at the sub-synchronous frequency are reduced quickly, improving the stability of the grid.

TRENDS

The SSCI management algorithm has been verified by Ingeteam and it is available for the field under the INGECONTM product series, see Figure 5. The intelligent power converters could have a key role in future grid configurations. In fact, the development of new technologies, oriented to provide intelligence to power converters such as the ability of identify, characterize and operate properly under any undesirable grid condition, could ensure the optimum operation of the future power system in a reliable and efficient way.

Children's Book: Talking Turbine Wins Young Hearts and Minds

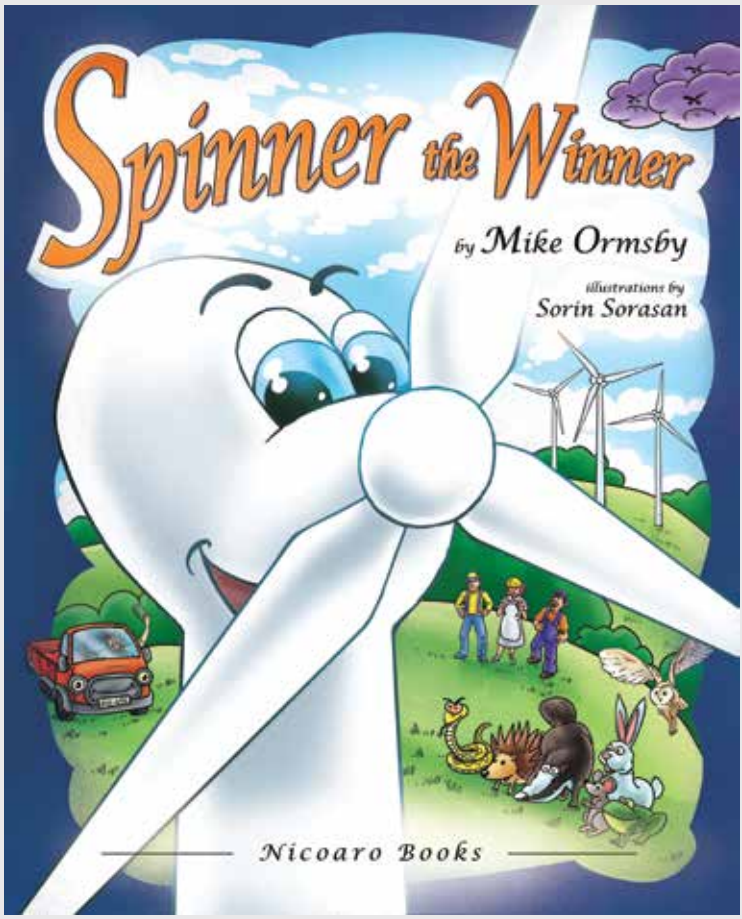
How do we explain the function and technical aspects of a wind turbine to an inquisitive young child? If you've ever wondered, help is at hand in the shape of Spinner the Winner, a new picture book for children.

British author Mike Ormsby is based in Azerbaijan. Ormsby said he got the idea for the talking turbine while working on assignment as a journalist.

"I was with BBC Wales in the early '90s and reported on a row about a wind farm. I'd never seen a turbine up close; their elegance and personality impressed me. The nacelle is like a face. I noticed some confused kids, too…

Spoiler alert! Here's the plot…

Spinner is a young turbine, separated from his family on installation day. He develops a squeak and is vandalized by villagers. He's alone, unloved and unhappy. But when a windy storm causes a blackout, Spinner triumphs over prejudice and adversity to save the day, winning hearts and minds.



"It's about how turbines generate power AND controversy," Ormsby said. "I stashed the story for 20 years, until my wife spotted its potential for self-publishing. She found an illustrator from Transylvania, Sorin Sorasan. We spent 10 months preparing to publish in two editions—full color, plus black and white for younger kids to color-in. Corporate sales took off, from day one."

Four big players in European wind energy—CEZ, GDF Suez, ENEL and RWEA—have sponsored a branded Romanian translation. The book will soon be translated into French and Serbian. The English version is doing well on Amazon, downloaded free almost 3,000 times recently and recommended by the online educational resource, Kid Wind Project. Ormsby said he hasn't profited from the book yet, but remains optimistic. "The main thing is, kids love it. That's crucial," the author said. "One lad asked if Spinner would ever be a cartoon on DVD. They're always one step ahead!"

For more information about "Spinner the Winner," visit www.spinnerthewinner.wordpress.com. Also, log on now to the *Wind Systems* Facebook page (www.facebook.com/windsystemsmag) for a chance to win one of two free copies of the book.

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

ITL's IFH-1710 Offers Latest Technology in a Space-Saving Package

International Tower Lighting, LLC's integrated wind turbine obstruction lighting system, model IFH-1710, utilizes the latest in LED technology and advanced polymer optics to achieve a compact, low-power solution for marking wind turbines. The integrated design of the IFH-1710 requires virtually no space inside the nacelle.

Certified to meet FAA requirements for wind turbine farms, the IFH-1710 features wireless GPS flash synchronization without the need for external components. The universal input power supply is capable of operating from line voltages world-wide and utilizes metal oxide varistor (MOV) and gas discharge tube (GDT) surge suppression for harsh electrical environments.

For ease of installation the IFH-1710 is delivered pre-wired with a single shielded cable, rated TC-ER (tray cable, exposed run) to meet NEC requirements for exposed runs.

The IFH-1710 is designed for long-term maintainability. The hinged cover allows access for testing and maintenance yet is securely fastened using stainless steel draw latches.

Unique for wind turbine obstruction lighting systems, the IFH-1710's modular design allows for field replacement of circuit boards, photocell and GPS. A push-button-operated self-test requires no communication devices or computers to operate. A novel fail-safe feature turns the light on solid in the event of a flasher failure.

Capable of matching the flash rate of competitors, the IFH-1710 can be integrated into your existing portfolio of lighting systems.

For more information, visit www.itl-llc.com, or call 866-624-8309. Visit International Tower Lighting at WINDPOWER 2013 at Booth 2401.

Red Dog Mobile Shelters Brings Certified Safe Rooms Wind Industry

Tornadoes and wind turbines all too frequently compete for the same geography throughout the areas of the U.S. known as "Tornado Alley". Whether it's a wind turbine or a drilling rig that gets in the way of the average tornado, the outcome is certain. With green energy efforts growing so will be the frequency of wind-farms being struck by tornadoes.

As bad as the loss of multiple turbines is to a producer, the personal, legal and economic loss from injury to crews erecting and servicing these structures is potentially far greater. But installation of permanently anchored industrial quality tornado protective "safe rooms" near each tower is not feasible. Addressing this safety problem, Red Dog Mobile Shelters LLC designed and patented the only mobile safe room certified to meet every known tornado shelter standard issued by FEMA, the International Code Council (ICC-500), the National Storm Shelter Association (NSSA) and the American Society of Civil Engineers (ASCE).

Unlike conventional designs that require massive foundations to anchor shelters against wind forces, Red Dog's new technology uses aerodynamics to eliminate the need for anchoring by turning the destructive winds of a tornado into a stabilizing force even in EF-5 storms exceeding 300 mph. The faster the wind the more stable the shelter. Unique structural configurations and materials of construction enable the units to support over 1,000,000 pounds of dead load while fending off full force impacts by rotor blades falling from 150-foot heights.

The massive 250-pound doors are ADA compliant with internally activated, self-releasing hinges to prevent residual storm debris from trapping occupants inside and have passed impact tests conducted by Texas Tech Wind Science and Engineering Research Center. Electronic site alarm packages convert NOAA weather warnings into both visual strobes and 140-decibel audible warnings alerting distracted workers, contractors and visitors of approaching tornadoes.

Relocation of the 32-person-rated shelters only takes minutes and requires no DOT permits. Rapid deployment makes possible having a safe refuge immediately available for workers regardless of the short duration nature of servicing multiple work sites. Optional features allow the multi-functional safe rooms to replace other on-site structures such as office space, cooling rooms, heat stress recovery spaces, safety meeting rooms and break rooms thereby decreasing a site's footprint needed for crew support accommodations.

For rental information, visit www.lighttowerrentals.com or call 432-530-3330.

Hughey & Phillips Now Offering Dual Medium-Intensity LED Strobe System

Hughey & Phillips announces the new HORIZON™ line of medium-intensity strobe LED based obstruction lighting solutions for daytime and nighttime lighting on tall structures such as communication, television and radio towers, wind turbines, smokestacks and other obstructions to aerial navigation.

Intertek (ETL) certified and Federal Aviation Administration (FAA) approved, the L-864/865 provides both daytime white and nighttime red lights within a single unit, and is part of the newest addition to H&P's obstruction lighting portfolio, the HORIZON™ line. The series is available in L864 (Red), L865 (White) and L864/L865 (Red/White). Daytime white strobe eliminates the need to paint the structure with aviation orange and white stripes, and nighttime red flashing beacon lights are community friendly. The HORIZON™ L-864/865 is best suited for structures between 150' (45 m) and 500' (150 m) above ground level and operates at a range of 95-277VAC, 50/60Hz.

The new microprocessor controlled LED strobe system boasts a self-contained power supply that simplifies wiring but also accepts external signals if necessary. Its compact design, built-in testing, GPS sync, automatic day/night sensor and wiring compatibility make the product easy to use and install. Like other products in the HORIZON™ line, the units are compatible with existing cable systems in most cases, allowing users to retrofit to LED without purchasing entire new systems.

H&P HORIZON™ system uses 90 percent less power than incandescent medium intensity models, and is designed, built, and sourced in the U.S., using domestic suppliers. There are more than 20 patents pending on components and features of the HORIZON series. The system comes with a five-year warranty and has an expected life of more than 15 years. It is the only unit in the market to be completely serviceable, ensuring a longer life than any competitor models.

For more information, visit www.hugheyandphillips.com, or call 937-652-3500. Visit Hughey & Phillips at WINDPOWER 2013 at Booth 4107.

ADINDEX

John Doss
general manager, renewable resources, Bridgewell Resources

TELL ME A LITTLE ABOUT YOUR POSITION AND ROLE AT BRIDGEWELL RESOURCES.

I've been with Bridgewell Resources since its inception, mostly in a sales role. I was an international sales manager for the utility and construction division. Several months ago, the company formed its renewable resources division. They asked me to be the manager of that. So I moved out of utility and construction division and into the renewable resources.

WHAT IS BRIDGEWELL RESOURCES, AND WHAT PRODUCTS AND SERVICES TO THEY OFFER?

Bridgewell is actually comprised of eight operating divisions. We basically span the gap between our suppliers and customers as a global wholesale distributor, sales organization and supply chain manager. Among our product offerings are: Wood products; food and agricultural products; heavy industrial products; building materials; specialty building products; and renewable resources.

YOU MENTION THAT THE RENEWABLE RESOURCES DIVISION IS RATHER NEW. HOW DID IT COME ABOUT?

Until recently, Bridgewell was promoting the wind and solar business as part of its utility pole business through our utility and construction division. We first started on a couple of wind projects and then picked up a few solar projects. The president and the chairman of the board of the company took note of the size and scope of the projects we were planning to undertake, and the need to devote more resources to these projects down the line. A separate division allowed us to promote the individuality of the products that we were trying to sell, as opposed to being focused on utility companies. The renewables products are aimed at a lot of different applications—commercial, utility, even residential applications.

WHERE DOES WIND ENERGY STAND IN COMPARISON WITH BRIDGEWELL'S OTHER PRODUCTS?

From an overall sales perspective, our renewable energy division will contribute between 4–5 percent of total gross sales for Bridgewell next year. That's been a pretty steady number historically—going back to before the creation of the renewables division.

WHAT ARE SOME OF THE PRODUCTS AND SERVICES WITHIN THE WIND/RENEWABLE SEGMENT THAT YOU OFFER TO YOUR CUSTOMERS?

Currently, we're involved mainly in small and community wind. We're not in utility scale. Our other renewable products are solar and biomass. What we offer to project developers, EPCs, and in some cases construction firms is a wholesale equipment package. This could include towers, turbines, minor materials, and in some cases wires and transformers. The equipment package is crafted and tailored for their individual project needs. We also offer logistics, procurement support, and warehousing as necessary. Our goal is to make sure that the product mix that they need for their specific project arrives in an efficient manner and that we support them through the development stage of the project.

WHEN YOU SAY "NOT IN UTILITY SCALE," DOES THAT MEAN YOU WORK WITH COMMUNITY WIND OR SMALL WIND OR BOTH?

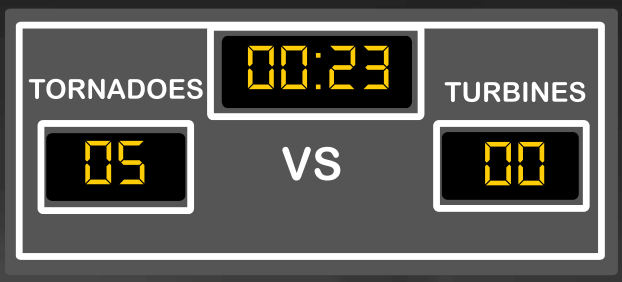
An example project would be a large agricultural farmer in a remote location who is looking for an efficient way to offset some of their electricity bills associated running their irrigation systems. It's the same think with same way the wastewater treatment facility or a school or a local municipal district. That's really our target customer. Our role is to provide the product and support the development of the project through the commissioning and construction phase. Typically, our customers are behind-the-meter, distributed generation projects.

WHAT IS THE BIGGEST ADVANTAGE THAT BRIDGEWELL CAN OFFER TO A PROJECT DEVELOPER?

We're more than just a typical distributor, in that we partner with the project developer and we bring a lot of technical expertise, and we're really flexible. When we get into a project with a project developer, we're their partner. Our interests are aligned with project developers and we think we can be a very valuable resource to them. Wind is a growing segment. As costs continue to come down and efficiencies in the supply chain continue to improve, wind will become more competitive with other renewable technologies, specifically solar. We want to be a driving force in that.

For the complete Q&A with John Doss, visit windsystemsmag.com.

For more information about Bridgewell Resources, visit www.bridgewellresources.com or call 800-570-3566.



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Unfortunately,
Mother Nature
has a Mean Streak.
Fortunately, you have Sika.
Face it, Mother Nature doesn't always play nice with wind turbines. High winds, hail, lightning, snow, ice, and even birds can damage blades, reducing their capacity to perform. When that happens, you need fast, reliable repair products and services that can get your turbines back on line. That's why the world's leading wind turbine producers consistently turn to Sika. Our expertise and experience in the wind energy industry are second to none with a full range of repair products that consistently meet the industry's toughest specifications. You can't stop Mother Nature when she gets mean, but fortunately you have Sika to get turbines turning again. For more information, visit www.sikausa.com or call 248.577.0020.
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