DECEMBER 2011

WIND SYSTEMS

FEATURES

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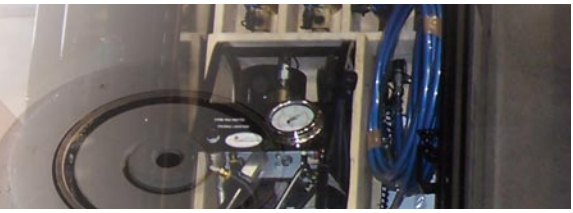

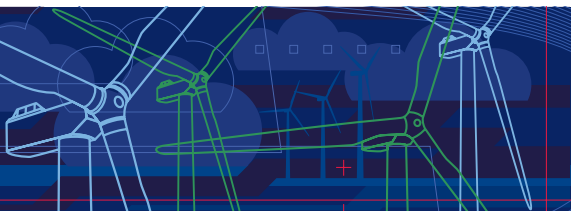

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EDLETTER

It's interesting to consider how unexpected themes can sometimes arise within an issue. While I do my best to assemble articles that work together, we also want to cover as much ground as possible each month, so it's a nice surprise when unintended connections appear within the gestalt. Sometimes that theme will involve emerging technologies, site assessment, or economic development. Strategic planning seems to be the *deus ex machina*—or the ghost in the machine—this time around, with many of our articles addressing the topic from different perspectives, and it's also a thread running through some of our columns, our profile, and our Q&A as well.

As an example, Lauren Berry of the Inland Marine division of Travelers has penned "Protecting Wind Energy Investments," encouraging wind developers to seek coverage to help manage risk throughout the lifecycle of the operation, and Chris Pattison of SGS Engineering also endorses a strategic approach in "Advance Planning for Efficient Operations." Jeff Grandgenett of Mankiewicz Coatings discusses BladeRep products in "Battling Exposure with Blade Coatings," and Srinath Srinivasan of Load Control Technologies describes the i-Bolt ultrasonic fastener in "Advances in Bolting Technology." Curt Collins of Pacific Crest Transformers asks whether your step-up transformer is the wink link in the chain in "Transforming Outages into Uptime," and Lu Li, Dave Watson, Chet Socha, and Kristen Berard of Alpha Wire suggest that cable construction and test data should be evaluated prior to being selected in "Flexing Cable for Wind Applications."

As for our columnists, Merritt Brown of Rev1 Renewables continues his discussion of preseason winter preparations in his maintenance column, while Michael Graska of the Professional Logistics Group endorses taking a 3D approach to considering the interactions between weather and terrain at wind farm sites. Susan Stewart of Penn State's Wind Energy Program says that conversion factors are needed in order to properly navigate the relative interpretation of time-averaged extreme wind conditions in various standards and data sources, and Ron Krizan of the NAES Corp. writes that understanding the importance of field tiles will help lower overall construction costs, among other benefits. It was a pleasure speaking with Tom Smith about his company's history and capabilities—he does a great job of explaining how Alltite, Inc., provides "total bolting solutions"—and Troy Hewitt, global wind energy business leader at Intertek, was very kind in taking the time to explain the many important roles he and his colleagues are playing within the wind industry. This is a company that goes back 126 years and can claim Thomas Edison as a catalyst in its early development, so please visit their Web site to learn more because we couldn't possibly cover its full range of wind-related services in a single page.

As we close out 2011 and welcome 2012, all of us here at *Wind Systems* magazine look forward to working with you on upcoming issues. Please do not hesitate to contact me at the e-mail address listed below to discuss any story ideas you may have—with a little strategic planning, we can help each other succeed in the New Year!

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ALSTOM LAUNCHES ECO 122 TURBINE FOR LOW WIND SITES

Alstom announces the launch of the ECO 122, a 2.7MW onshore wind turbine that combines high power and high capacity factor to boost energy yield in low wind regions worldwide. The ECO 122's leading efficiency and high yield set a new benchmark for low wind sites. At a wind speed of 7.5 m/s the turbine delivers a net wind farm capacity factor of up to 42 percent, equivalent to 3,600 full-load hours each year. Its 122-metre rotor diameter and swept area of 11,700 m^2—the largest in the 2-3MW turbine segment—maximize the harvest of energy and the return on investment to create new business opportunities for customers from low wind sites.

Alfonso Faubel, senior vice president of Alstom's wind business, says "Research and innovation are at the heart of our business. With the ECO 122 and other turbines in our ECO 100 platform, we're leading the development of the new generation of high power, high-efficiency turbines to increase value for our customers. Longer blades capture more power more effectively, and with its swept area much larger than current generation machines, the ECO 122 has set a new standard for low wind sites around the globe."

The ECO 122 produces about 25 percent increased wind farm yield on a given piece of land compared with today's 1.5-2MW turbines, and fewer turbines need to be installed. As an example, on a typical low wind site, six current generation 1.5 - 2 MW turbines will produce around 40 GWh/year, compared with more than 50 GWh/year with only five ECO 122 turbines. This yield advantage also means significant capital expenditure savings. An ECO 122 powered wind farm can reduce balance of plant costs by 10-15 percent, compared with a farm using typical 1.5-2MW machines, due to fewer foundations, platforms, roads, and less cabling.

The ECO 122 is the latest evolution of Alstom's proven ECO 100 turbine platform, and the result of more than 30 years of experience in wind turbine design. The ECO 100 platform now has more than 350MW installed or under construction worldwide and over 200,000 cumulative operating hours since 2008. All Alstom wind turbines are based upon

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

the unique and proven ALSTOM PURE TORQUE® rotor support concept that protects the drive train from deflection loads, ensuring higher reliability and lower maintenance costs. The first ECO 122 will be installed in mid 2012, with first commercial deliveries expected in early 2013. Learn more at www.alstom.com/wind.

NRG SYSTEMS INVESTS IN LATTICE TOWER MANUFACTURER

NRG Systems, manufacturer of measurement systems for the renewable energy industry has agreed to invest in Oenko, a manufacturer and installer of lattice towers for wind resource assessment and wind farm monitoring. This investment pairs NRG Systems' nearly 30 years in the wind energy industry and its complete system approach with Oenko's cutting-edge lattice tower technology. "This line of lattice towers complements our existing tower offerings," says Barton Merle-Smith. "Our investment enables us to offer customers greater choice in towers, booms, and mounting hardware, meeting the full range of customer needs anywhere in the world."

Based in Thetford Mines, Quebec, Oenko designs and manufactures lattice towers from 30 to 120 meters for all types of project sizes and locations, specializing in extreme arctic conditions. NRG Systems, based in Vermont, pioneered complete measurement systems with tubular tilt-up towers in the 1980s. "I am pleased that Oenko has attracted the investment of NRG Systems," says Guy Fortin, president of Oenko. "This will enable us to expand globally while continuing to grow jobs in Thetford Mines."

As a result of the investment, NRG Systems will hold a majority interest in Oenko. Manufacturing will remain in its current location with Oenko's existing workforce, while Fortin will continue on as president and key sales person for the company. For more information visit www.oenko.com.

NRG Systems is an independently owned company that has served the global renewable energy industry since 1982. Its wind measurement equipment can be found on every continent in more than 145 countries, serving electric utilities, wind farm developers, research institutes, and government agencies. The company has been nationally recognized for its LEED gold-certified manufacturing facility and its employee best practices. To learn more go to www.nrgsystems.com.

WIND ENERGY MANUFACTURING LAB AT IOWA STATE

A laser in Iowa State University's Wind Energy Manufacturing Laboratory scanned layer after layer of the flexible fiberglass fabric used to make wind turbine blades. A computer took the laser readings and calculated how dozens of the layers would fit and flow over the curves of a mold used to manufacture a blade. And if there was a wrinkle or wave in the fabric, any defect at all, the technology was designed to find it. That's because the last thing you want is a defect in a 40-meter wind turbine blade when it's spinning in the wind.

"Waves in the fabric are bad because they can't take the load," says Vinay Dayal, an Iowa State associate professor of aerospace engineering. "And if a blade can't take the load, bad things happen to the turbine," according to John Jackman, associate professor of industrial and manufacturing systems engineering.

The two are working with Frank Peters and Matt Frank, associate professors of industrial and manufacturing systems engineering, to operate and develop Iowa State's Wind Energy Manufacturing Lab. The lab has been open for about a year and was built as part of a three-year, $6.3 million research project. The study is a joint effort of researchers from TPI Composites, a Scottsdale, Arizona-based company that operates a turbine blade factory in Newton, and the U.S. Department of Energy's Sandia National Laboratories in Albuquerque, New Mexico. The researchers' goal is to develop new, low-cost manufacturing systems that could improve the productivity of turbine blade factories by as much as 35 percent.

The lab in Iowa State's Sweeney Hall provides researchers the facilities and equipment they need to study how lasers can analyze the fiberglass fabric that's used to manufacture turbine blades; develop technology for the nondestructive evaluation of turbine blades; analyze and improve wind blade edges; make precise 3-D laser measurements of 40-meter wind turbine blades; and develop new fabric manipulation techniques for automated blade construction.

Researchers say the lab has already advanced their understanding of turbine blade manufacturing and is helping to develop automation technologies that could one day be used in manufacturing plants. "In the early stages of the research there were a lot of investigations to understand all the problems we're addressing," Frank said. "But now we're at that phase where real intellectual property is coming out of the lab." Learn more at www.iastate.edu.

MORTENSON BUILDS FIFTH WIND FACILITY IN ILLINOIS

Mortenson Construction has started construction of the Shady Oaks Wind Farm near Compton, Illinois, adding 109.5MW to the state's wind energy capacity. The wind power facility will consist of 71 Goldwind turbines. Mortenson is responsible for the design and construction of access roads, collection system, foundations, and the erection of

the turbines. The Shady Oaks project will be the fifth utility-scale wind facility that Mortenson has constructed in Illinois, bringing the total number of turbines erected in the state to 541 upon its completion. Construction started in late August and is expected to be complete in early 2012.

According to the Illinois Wind Energy Association, an average 100MW wind farm in Illinois creates 125 to 150 temporary construction jobs and 10 permanent maintenance jobs, which is consistent with the number of jobs that will be created with the Shady Oak Project. "The Shady Oaks project is the first partnership of Mortenson and Goldwind and the first major wind project in the U.S. to utilize the advanced Permanent Magnet Direct Drive Technology (PMDD)," according to Tim Maag, a vice president and general manager of Mortenson's Renewable Energy Groups.

"We selected Mortenson as our construction partner for the Shady Oaks project because of their outstanding track record of success with wind farm construction and because of the commitment to on-site safety," said Tim Rosenzweig, CEO of Goldwind USA. "We are pleased to be working with Mortenson on this important project."

The Goldwind portfolio of 1.5 and 2.5MW permanent magnet direct-drive wind turbines are designed for high power generating efficiency, superior power quality and grid code compliance, and significantly reduced maintenance and total operating expenditures. The simplistic permanent magnet direct-drive design reduces the number of high-speed rotational parts and avoids the sources of expensive faults that require crane mobilization.

Founded in 1954, Mortenson Construction is a U.S.-based, family-owned company that has constructed more than 100 wind projects generating more than 11,000MW of renewable power throughout the United States and Canada. Visit www.mortenson.com/wind. With offices and facilities throughout Asia, Europe, and the Americas, Xinjiang Goldwind Science & Technology Co, is ranked among the leading wind turbine manufacturers in the world. Learn more at www.goldwindamerica.com.

SECOND WIND SYSTEM IN TURBINE WAKE EFFECT STUDY

A Colorado-based research team recently completed a major wind study using Second Wind's Triton® Sonic Wind Profiler to learn more about one of wind power's biggest unknowns, the wake effect, and its impact on turbine productivity. Triton is one of several remote sensing technologies that TWICS (the Turbine Wake and Inflow Characterization Study) has used to create a detailed 3D model of the turbulence caused when wind passes over rotating turbine blades. Turbulence can damage turbines downstream and undermine productivity. The project's goal is to understand how to enhance wind farms' productivity. Turbine inflow and wake observations will be integrated into a wind energy forecasting model. Understanding how gusts and rapid changes in wind direction affect turbine operations will enable turbine manufacturers to improve design standards and increase efficiency, which will ultimately reduce the cost of energy.

The study is aimed at capturing turbulence and other wake effects in a broad wedge of air up to 7km (4.3 miles) long and 1km (3,280 feet) high in front of and behind a multi-MW wind turbine. Triton, along with tower-mounted sensors and other remote sensing systems, profiles the winds in front of and behind a 130-meter high wind turbine located at the National Renewable Energy Laboratory's (NREL's) National Wind Technology center near Boulder, Colorado. NREL, the University of Colorado at Boulder, the Cooperative Institute for Research in Environmental Sciences (CIRES), and the National Oceanic and Atmospheric Administration (NOAA) have teamed up to conduct the study.

"The NREL site is prone to complicated wind patterns, so we needed several remote sensing instruments. The site is flat, but it's located just five kilometers from El Dorado Canyon on Colorado's Front Range and the canyon funnels air into the site," says Julie Lundquist, assistant professor of atmospheric and oceanic sciences at the University of Colorado at Boulder. "The Triton is a good instrument for this study. It will provide us with anchor points in the study by profiling selected slices of a larger wedge of the atmosphere over a long period of time."

Triton is an advanced remote sensing system that uses sodar (sound detection and ranging) technology to measure wind in the areas that most affect a wind turbine's performance. By measuring wind speeds at the turbine rotor's hub height and beyond, Triton reduces uncertainty in annual energy production (AEP) forecasts. Easy to install and capable of autonomous operation, Tritons are being used throughout the wind industry, alone or in conjunction with met towers, to streamline the wind farm development process and to improve wind farm operations.

"Turbine wake effects are a huge unknown in the wind industry. To fully realize the potential of wind energy, with large-scale wind farms, we need to know how turbulence from one turbine affects those around it," says Second Wind CEO Larry Letteney. "We're confident that Triton will make a significant contribution to understanding wind farm conditions, which will lead to a more productive and efficient wind power industry."

Second Wind provides the wind energy industry with the intelligence required to plan, finance and operate highly efficient, profitable wind generation facilities. Learn more at www.secondwind.com.

CAPITAL SAFETY INTRODUCES EXOFIT NEX ARC FLASH HARNESSES

Capital Safety announces a new extension to its revolutionary DBI-SALA ExoFit NEX™ product line,

the ExoFit NEX Arc Flash harnesses. The innovative harnesses incorporate Nomex/Kevlar technology into their design and feature flame-resistant and non-conductive properties, making them perfect for use in any industry that involves exposure to high-voltage electricity or hot work, such as welding.

The new harnesses are tested to perform in

accordance with the recently updated ASTM F887-11 arc flash standard specification for personal climbing equipment, as well as ANSI Z359.1 and CSA requirements. The ExoFit NEX Arc Flash harnesses are a result of ongoing research and development within the ExoFit NEX line, and incorporate technical advancements in materials and features.

"When the ASTM standard was updated to include harnesses and shock absorbing lanyards, DBI-SALA was one of the first to introduce these products to the market," says Nate Bohmbach, product manager for soft goods at Capital Safety. "We have worked closely with linemen, welders, and other members of the utility, construction, and mining industries to create the best arc flash harnesses in the world featuring flame and heat protection. These harnesses offer the same level of comfort and safety as the original models with the added arc flash protection and confidence needed in high-voltage or hot work environments."

The ExoFit NEX Arc Flash harnesses are equipped with flame-resistant webbing; an exterior made with Nomex, featuring a Kevlar core and thread that provides 7,000 lb. strength and ultimate flame resistance. The built-in arc flash rated trauma straps provide an adjustable, continuous loop that minimizes suspension trauma. The integrated insulators behind exposed hardware prevent contact with the body ideal for use in utility industry applications. The non-conductive, extremely lightweight PVC-coated aluminum D-rings are another industry first from DBI-SALA. All featured hardware on the ExoFit NEX Arc Flash harness offers the highest level of comfort and security. Its superior design is equipped with i-Safe™ technology, which allows it to be tracked in inventory and tagged with usage data. These harnesses meet all applicable industry standards including OSHA, ANSI, CSA, and ASTM. Learn more at www.capitalsafety.com.

NEW GLOBAL PRESIDENT AT SANDVIK COROMANT

On September 1, 2011, Klas Forsström took over the position as global president of Sandvik Coromant, the world-leading supplier of cutting tools, tooling solutions, services, and know-how to the metalworking industry. Forsström has been with the Sandvik Group for about 17 years, mostly at Sandvik Coromant. His work has included leading positions in R&D, product development, marketing, business development, and sales. Most recently he held the position as president of Sandvik Hard Materials.

"It is really exciting and inspiring to be back with Sandvik Coromant. I am truly impressed by what the company has achieved in recent years. As the market leader we are perceptive and forward thinking," he says.

His first task as president is to manage and further develop the ambitious strategy that Sandvik Coromant has set. This includes an even stronger customer focus through local presence and global knowledge sharing. "R&D is part of the very fabric that is Sandvik Coromant. We are always focused on product innovation, premium application knowledge and speed to market. Our ambition and motivation for the future is strong. I believe we will be successful in the further development of customer oriented solutions," he explains. Short facts about Klas Forsström:

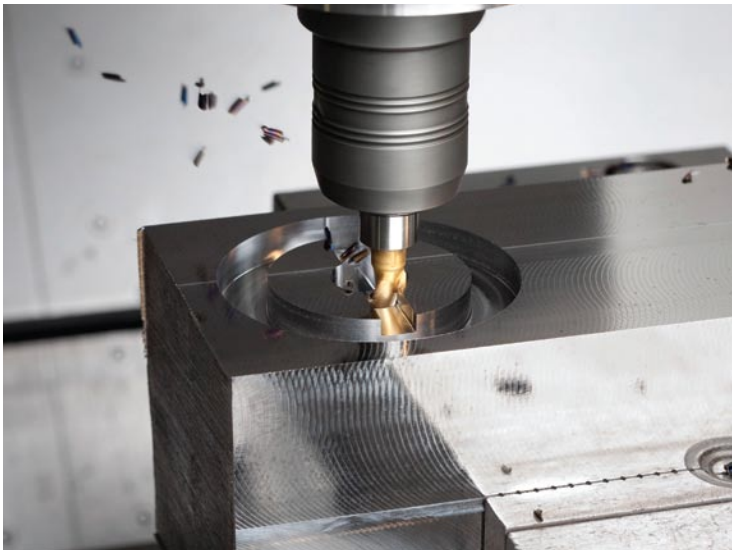
- Education: Klas Forsström holds a Master of Science in Materials Physics and a BMA from Uppsala University, Sweden.
- Born: 1967 in Gävle, Sweden.
- Family: Married to Marie Forsström; children: Matilda, Lovisa, Amanda and Erik.
- Lives: Sandviken, Sweden
- Interests: Family life, reading, fishing, and carpentry.

Sandvik Coromant is the world-leading supplier of cutting tools and tooling systems for the metalworking industry and is represented in 130 countries. Twenty-five state of the art Productivity Centers located around the world provide customers and staff with continuous training in tooling solutions and methods to increase productivity. Sandvik Coromant is part of the tooling business area of the Sandvik Group. Learn more at www.sandvik.coromant.com/us.

SECO ADVANCES MILLING TECHNOLOGY WITH MINIMASTER

Seco introduced its original Minimaster line of end mills with replaceable carbide inserts nearly 25 years ago. Today the company is presenting its new Minimaster Plus, with advanced features for tackling the most demanding of milling applications in steel, stainless steel, cast iron, aluminum and other difficult-to-machine materials.

The most notable new feature on the Minimaster Plus is the high-precision interface between the replaceable carbide insert and the steel shank. The insert has an internal thread and external taper, while the shank has an internal taper with a threaded center pin for added reliability and stability as well as minimized run-out. Additionally, a new axial stop on the shank increases repeatability and productivity by allowing end users to replace an insert without having to remove the tool from machine spindles. The new insert then repositions axially within 25 microns.



Intended for general machining in the aerospace, power generation, die and mold, automotive, and medical industries, the highly productive Minimaster Plus replaceable tip milling system makes tool-length re-measurement obsolete. The milling system offers a large selection of inserts and shanks for a multitude of tough milling applications. Twenty-four versions of the shank are available, along with square shoulder and ball nose inserts that have through-tool coolant on all two and three flute designs for excellent cooling and efficient chip removal. Inserts come in two grades for

machining all types of materials and E- and Mgeometries for a smooth cutting design. Insert diameters range from 0.375" to 0.625" and corner radii are available from 0.0157" to 0.122" to match a variety of design requirements. For more information visit www.secotools.com/us.

PACIFIC CREST ANNOUNCES RESULTS OF SEISMIC TESTING

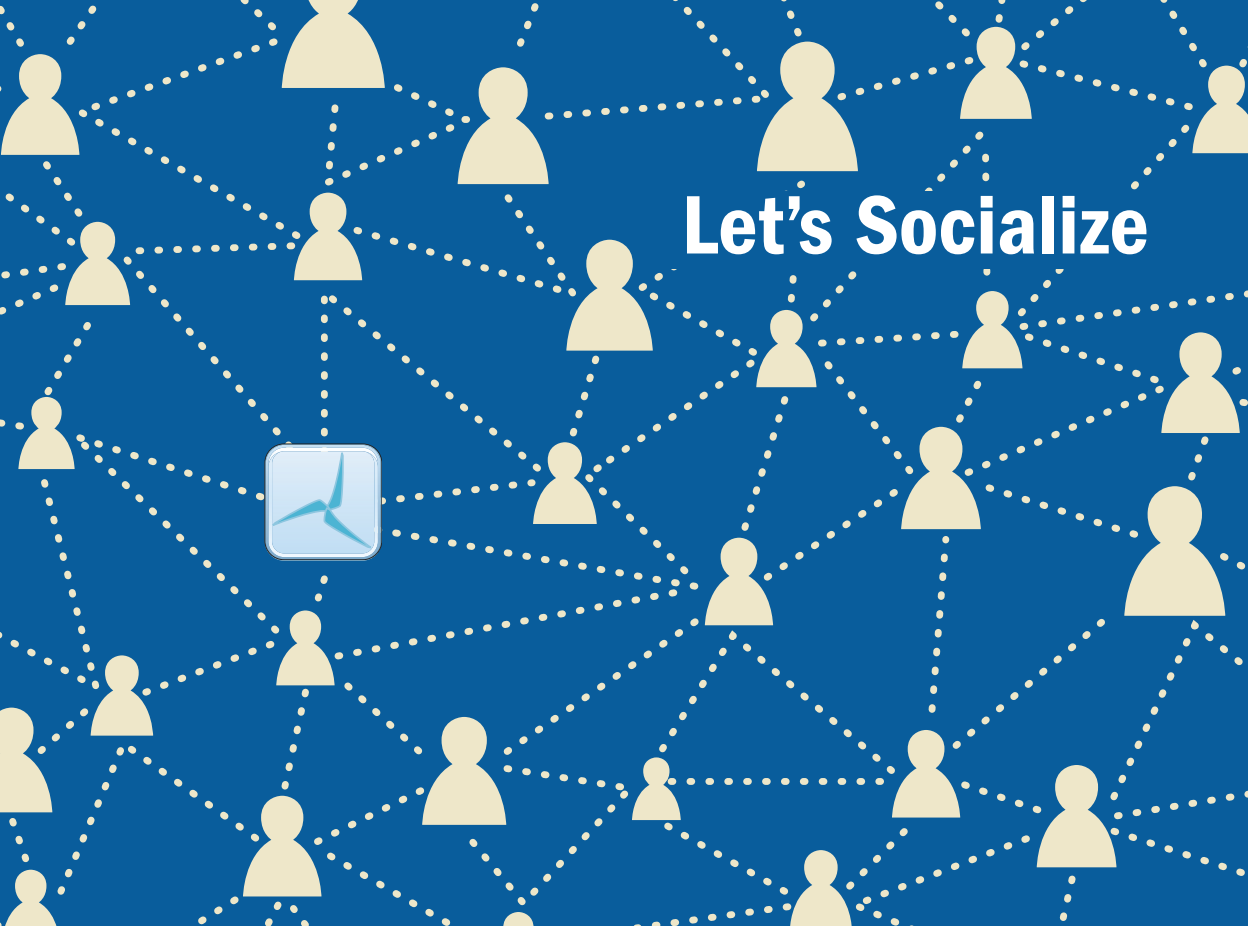
Pacific Crest Transformers (PCT), a leader in the design and construction of liquid-filled distribution transformers, announces that its transformer withstood rigorous seismic testing performed at one of the nation's largest independent engineering testing laboratories. The testing showed that PCT's transformer design and construction is suitable for mission critical applications, including hospitals, command centers, and generation stations.

The same transformer was subjected to tests simulating six violent earthquakes over two days, each equating to real potential events from different extreme seismic zones of the country. The transformer was energized during the tests. The final two tests were designed to simulate the worst potential earthquake in the Unites States, the New Madrid Fault, located under a four-state area that includes Arkansas, Missouri, Tennessee, and Kentucky, but with the potential to affect an even larger region. In each of the tests, the transformer continued to operate throughout and sustained no internal or external damage. The transformer passed Hi-Pot tests and IEEE Routine tests performed before and after the shake table testing, which showed it withstood the shake tests without diminishing its operational performance.

The testing program was conducted by Wyle, one of the world's most experienced qualification testing operations, which provides services to a wide range of industries, as well as the aerospace and U.S. Department of Defense arenas. PCT conducted the testing at Wyle's Huntsville, Alabama, laboratory, which specializes in testing and qualifying equipment for the energy and nuclear power industries, automotive companies, and other high-technology industries, as well as DoD missile, aviation, ground applications, and NASA.

"No one transformer would be expected to experience more than one of these events over its lifetime and PCT's transformer survived the entire gamut of possible events," says Curt Collins, Pacific Crest Transformer's Vice President of Sales and Marketing. "This illustrates the rugged, robust construction and designed-to-task quality that customers can expect from PCT." Learn more at www.pacificcresttrans.com.

Typographic errors found in a graphic accompanying "Innovative Drive Train Design" by Winergy Drive Systems in the September issue have been corrected online. Please go to www.windsystemsmag.com to view the correct information in the technical specifications found on page 29. Also visit www.winergy-group.com.



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WIND SYSTEMS

Ron Krizan, P.E.
NAES Corporation

Understanding the importance of field tiles and identifying ways to mitigate issues will help to improve landowner relations and lower overall construction costs.

NOTHING IS SIMPLE WHEN DEALING with tiling issues on wind facilities in certain portions of farm country. They are almost never surface located as part of a typical "one call" or underground utility location service. Most, if not all, of the tiles are poorly mapped and cannot be identified until they are encountered in the field. Failure to identify underground tiling issues will result in negative landowner relations, and could potentially add tens of thousands of dollars to pay for avoidable crop damages. The key to minimizing issues with tiles is to start with a good plan and then work that plan as the project progresses and beyond.

The first step in the plan is to identify the possible locations you are likely to encounter tiling and recognize the importance of avoiding them or repairing them quickly. Tiling is usually very prevalent in the Midwest or in areas where the soils are typically heavy (clay based) and the overall terrain is relatively flat. Pattern tile systems are named as such since they usually form back and forth patterns typically laid out in the same direction as the crops planted above them. Depending on soil types and conditions, these tiles are buried three to five feet deep and are usually spaced parallel to each other, anywhere from 35 feet to 100 feet apart. At the ends of the fields they usually connect into a perpendicular main line, which then collects all of the subsurface water and allows it to discharge into either a drainage ditch or waterway. They may also link up with even larger main tiles that may be part of a water district or county drain tile system.

A single main line tile can service anywhere from several hundred acres up to several thousand if it is part of a drainage district or county tile system. Paying for severe crop damages that may likely extend off the established wind farm boundaries can be both politically and financially challenging. Many times the actual crop damage costs can be difficult to calculate and determine equitably.

The second step is to spend as much time as possible researching the areas that you intend to place the turbines, in addition to any areas where you may run the underground collector system or establish crane/equipment paths. The landowners and/or tenant farmers are the best place to seek information since most maintain firsthand knowledge of the size, type, and general location of the tiles on their property. While the maps they provide are usually not accurate from a surveying degree, they do provide precise details as to how many tile runs exist in a particular field and the general direction they are running. Utilizing that information, it may be possible to slightly adjust the layouts of a wind facility where it makes economical sense, such as running a slightly longer collector system that goes parallel with a pattern tile system versus perpendicular to it. Several thousand dollars of additional collector cable can be far cheaper than repairing multiple tile breaks and reimbursing crop damage. At a minimum, the information can be provided to the construction crews so that they can stay vigilant on the lookout of any suspected tiles in the construction zone.

Finally, utilize construction methods that minimize the impacts to existing tile systems. When laying collector and underground cabling near tiles, you want to use open trenching methods if at all possible. When cable is "plowed" the operator will have no idea if they damaged underground tile until drainage issues start appearing on the surface. Finding and repairing tile breaks in the vicinity of an energized collector cable can be a very time consuming and expensive undertaking, especially if you encounter an unknown pattern tile system.

Whenever possible layout access roads, haul roads, and crane paths in the same direction as the crops planted on the surface, which will help to minimize the overall amount of times you may encounter a tile. Most modern farm machinery is designed for low ground pressure and typically will not crush the underground tiling systems. However, modern construction equipment is designed for maximum traction and with crane weights exceeding 500 tons, it is safe to assume that most tiles that are crossed in the course of construction will be damaged and will require some sort of repair. Understanding the importance of field tiles and identifying ways to mitigate issues will help to improve landowner relations and lower overall construction costs.

Ron Krizan, P.E., is engineering manager for NAES Corporation, the world's leading provider of comprehensive services to industries that generate or consume power. He can be reached at ron.krizan@naes.com. Go online to www.naes.com.

Merritt Brown
Rev1 Power Services, Inc.

In this conclusion of a two-part series, the author continues his discussion of preseason winter preparations, providing insights on how to safeguard personnel during the long winter months.

IN THE OCTOBER INSTALLMENT OF THIS column we discussed various ways to prepare the wind turbine for winter operations. We continue our conversation by addressing the safety risks related to cold weather and how advance planning, and training, can avoid cold weather related injuries to the service team.

Most technicians know how standing for long periods on sub-zero steel deck plating can suck the heat right out of you. Not surprisingly, even an operator in sunny southern California will complain about the cold weather in January. For his counterpart in the Midwest, such highs in the fifties would be a welcome feeling where average temperatures can hover in the teens for weeks on end. Working outdoors in such conditions is not to be taken lightly. As part of any winter service preparation, refresher training in recognizing the effects and avoidance of hypothermia and frostbite should be high on the list before winter settles in. For an unprepared technician, the onset of hypothermia can be gradual over time and is often caused by working in cold weather with inadequately insulated clothing. Since there is no exact temperature where the environment becomes hazardous, technicians need to be prepared against a variety of weather conditions including wind, dampness, rain and snow. As part of the seasonal training, employers should encourage the use of layered clothing by their technicians; cotton on the inner layer to wick away perspiration, followed by wool or synthetics to retain body heat and an outside layer to shield from wind and moisture. The wind can quickly carry heat away from the body, and clothing that protects the body from its effect should be part of the winter gear that includes helmet liners, insulated gloves, and boots. A balance in maintaining the mobility of a technician must be considered as well, as cold weather clothing can inhibit dexterity. Gloved hands make it more difficult to manipulate controls and tools, and heavy garments make ordinary movement more difficult.

Technicians should understand that while it might feel easier to climb a tower in 30-degree weather as opposed to during a 90-degree day, their level of exertion hasn't changed. In fact, exertion in cold weather imposes significant factors that deceptively alter the body's ability to self-regulate hydration without the aid of insulated clothing or intake of additional fluids. Most people don't feel as thirsty when it's cold, and they drink less. This is because blood flow moves from the extremities to the body core and the fluid level in the central body remains elevated, thereby reducing the thirst response. Educating the field teams to increase their fluid intake during the winter months is essential to prevent dehydration caused by exertion. Since cold climates tend to be less humid, working in such conditions can cause significant water loss through the skin and lungs as a result of the dryness of the air.

Traversing in deep snow can also present both an issue of immense exertion and a very real hazard from the moisture it leaves after melting from body heat. Blowing snow will find its way not only into a breeched nacelle, but also into any crack or opening in cold weather clothing. Snow weighs on average between 5-10 pounds per cubic feet, and while this may not seem like much, manual shoveling is usually required to keep pathways clear and often to gain tower access for maintenance. Recognizing that more heart attacks occur in cold weather than in warm weather, technicians should be aware of their own capabilities and take frequent rests during such intense physical activity. The reason? Regardless of the level of health, very cold temperatures cause an increase in blood pressure and a better chance for blood clots.

Lack of acclimatization actually predisposes an individual to the cold stresses of hypothermia or frostbite. Working safely in cold weather means allowing short interval exposure until the individual becomes acclimated to working outdoors in low temperatures. Though it may not always be convenient for the service of a wind project, scheduling outdoor work during the warmest time of the day is a good safety policy during the winter months. Allowing frequent breaks in heated shelters and reducing the daily work pace may sound counterproductive, but the benefit will show itself in reduced cold-related injuries on the job.

Environmental factors in winter working conditions create the real possibility that cold related injuries may occur. Alongside appropriate work policies, technicians should be trained to recognize hazardous conditions and be made aware of the appropriate weather gear needed to protect them. With the proper training, safe work practices, and the right gear, outdoor work in cold weather can be safe and productive.

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

Susan W. Stewart, Ph.D.
Penn State Wind Energy

In order to properly navigate the relative interpretation of time-averaged extreme wind conditions in various standards and data sources, conversion factors are needed.

THE U.S. COASTAL ENVIRONMENT offers challenges to widespread offshore wind development compared to projects installed in Europe. The prevalence of hurricanes along the Eastern seaboard and the Gulf of Mexico will require additional considerations as the U.S. defines its design standards. These issues are being addressed by several groups, such as a recent National Academies Transportation Research Board Committee and the AWEA Large Wind Turbine Compliance Guideline Committee.

What can be confusing is in the definition of the external design condition or reference wind speed across conflicting time averaging and reference height conventions. For instance, the design standards for wind turbines often refer to a 10-minute average, 50-year return, extreme wind speed at hub height (e.g. IEC 61400-1). Meanwhile, the Saffir-Simpson scale for hurricane intensity is based on one-minute averages, and values are referenced at a standardized 10m height. Additionally, the American Society of Civil Engineers has defined a peak-gust map (ASCE 7) for use in minimum design loads for buildings. The values on this map are also at a height of 10m, but indicate a 3s gust. In order to properly navigate the relative interpretation of time-averaged extreme wind conditions in various standards and data sources, conversion factors are needed from empirical data. A suitable wind shear model is also needed to translate the data between 10m and turbine hub height (approximately 80-100m).

Time Averaging Conversions: The following information, from the archived literature, provides a means to estimate the conversion between various time-averaging extreme wind speed conventions. Based on information from Powell et. al (Wea. Forecast. 11, p.329-349) , the Atlantic Oceanographic and Meteorological Laboratory recommend the following equation for adjusting between a 10-min. average and a one-min average wind speed:

$$V_{10min} = \frac{V_{1min}}{1.12}$$

Additionally an estimation of 3s gusts from one-min. averages can be described by Hsu (Elec. J. Struct. Eng., 8, p. 77-79) as a function of the power law exponent , α, discussed below: $V_{3s} = V_{1min} * (1 + 2\alpha)$

The resulting equation that can be used to roughly estimate the conversion of 3s peak gust data to a 10-min. average is thus:

$$V_{10min} = \frac{V_{3s}}{1.12 * (1 + 2\alpha)}$$

There are also Gust Factor curves, such as that of Durst (Meteorol.Mag., 89, 181–186), which can be used to adjust between time-averaging conventions.

Wind Shear Conversions: Most extreme wind reference values are at a height of 10m above the ground or sea surface. Therefore, in order to interpret the value of extreme wind speeds at the turbine hub height—which is often 80-100m above the surface—for use of design standards, wind shear approximations are needed. Two methods are commonly used by the wind industry to define wind shear conditions: the Power Law, and the Log Law. The Power Law is defined here for the example case of a 10m reference height:

Power Law: $V_{hub} = V_{10}\left(\frac{h_{hub}}{10\ m}\right)^{\alpha}$

Where, V_{hub} is the wind velocity at hub height in m/s, V_{10} is the wind velocity at the reference height of 10 m in m/s and h_{hub} is the hub height in m. The parameter that defines the specific shear conditions is the exponent, α, which is often assumed as 0.11 for the offshore environment. For any wind development project there is a need for information on the 10-minute average extreme wind speed at hub height for the project site to determine suitability for wind turbine technologies in accordance with loading guidelines, such as those of the International Electrotechnical Commission (IEC) for the turbine's type certification. For instance, the maximum classification given by these guidelines (IEC 61400-1) are for a reference extreme wind speed of 50m/s averaged over 10min at hub height with a 50-year return. As it stands, if the extreme conditions estimated for a site exceeds this reference wind speed, a turbine specially built for the situation would be needed.

It is arguable that the extreme wind speed conditions experienced in U.S. coastal waters would be during a hurricane event, so as an example of using the above correlations the IEC standards are compared here with the Saffir-Simpson Scale. Using the relationships defined above, a 50 m/s (112 mph) maximum 50-year extreme wind speed for an IEC class I turbine at 80m would correlate to a39.8 m/s (89 mph) 10min averaged wind speed at 10m, and a 44.6 m/s (100 mph) one-minute averaged wind speed at 10 m, which is a category 2 hurricane based on the Saffir- Simpson scale. This example highlights the importance of these conversions, as extreme wind conditions along the coasts may be defined with reference to hurricane intensities.

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Logistics planning requires factoring in the interaction between weather and the terrain to be transversed — taking a 3D rather than a 2D approach.

AS THE SEVENTH CONSECUTIVE DAY of rain was drenching me in the middle of a project, causing delays and running up costs, I thought of a line by Longfellow—"The best thing one can do when it's raining is to let it rain." No matter how well you plan, Mother Nature can and will push back. But couldn't we do a better job of anticipating this? I like to think of this as "Logistics in 3D," visualizing the challenging and sometimes exciting elements during a project.

As logistic professionals we plan, lay out schedules, craft contracts, and constantly communicate data. Call this "Logistics in 2D," which is flat like a sheet of paper while 3D reminds us of the movie industry. Recognizing that a normal (flat) film lacks pop, a movie company will film it in 3D. It certainly adds excitement, but it also adds complexity and cost. 3D logistics is the flipside of the movie industry, in which Mother Nature is manifested in weather and terrain that provides the complexity, and it's always there. We are always working on making logistics as 2D as possible, but unfortunately this is not an option for us. Logisticians have to deal with those forces of weather and terrain and the consequences of those elements.

Considering weather during the planning phase of a project will increase the project's chances of making budget and delivery. Some specific examples of this might include: If the project is during what I call the transitional months, spring and fall, how will freezing and thawing affect transporting heavy loads? When welding on railcars during the hot summer months, have you considered how to keep the welders cooled by adding a tarp for shade? During winter months have you anticipated and planned for where standing water will freeze, as in the holds of barges, and do you have a plan to handle mud on the project site?

We would all like our project to be executed on flat, hard surfaces, in a straight line, and with room to pass each delivery on the return trip. Often this is not the case with wind projects, which are built where the wind is and not at the convenience of transportation. As with weather, not considering terrain will affect budget and delivery. A few more questions to ask include: If the road grades are high, are special low gear power units required? Are there very short but high grade rises in a road that trailers will have trouble spanning? Does the terrain force sharp turns which require widening, and are roads exposed to the elements such as snow or high winds?

Time and again I have experienced how weather, terrain, or both affect projects. A couple of examples are witnessing trucks stuck in snow because the route was along a ridge and subject to winter lake-effect snow when by routing the trucks on a longer but lower route they would have avoided this issue. The longer, safer route would have delivered the components on time. I have also dealt with barges with standing water in the hold—no problem at the journey's beginning in the south, but ending up with the cargo frozen in place in the north.

Weather and terrain always interact. Because of this, during the planning phase of logistics projects you should always incorporate these variables into the process. Here are a few considerations to ponder:

- For weather, don't only consider the averages, but also consider peak conditions.
- Ask if weather conditions require special equipment and procedures.
- Does the schedule have weather days built in, and have such delays been considered as it affects cost?
- Based on weather, are there special local requirements to be considered?
- For terrain, what are the maximum grades along the routes?
- Does the terrain require special equipment and procedures, or improvements?
- How does weather interact with terrain?

Project planning may not anticipate every issue that weather and terrain presents, but by being prepared you can alleviate most surprises. There are many sources of information that can be tapped to provide data for decisions. The National Weather Service is a good source for weather data, as well as the U.S. Geological Survey as a source for terrain information. However, I would suggest visiting the site and traveling the routes during the planning process. Doing this is an investment in the project planning phase that will pay dividends down the road. Local knowledge can provide valuable insights that would not be apparent without a visit.

Weather and terrain add exciting and challenging elements to logistics projects. It changes an ordinary 2D paper plan into a 3D production, and if you plan for a 3D project your chances of a blockbuster are greatly improved!

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ALLTITE, INC.

By Russ Willcutt

Over the past eight years this company has earned its reputation as a "total bolting solution" provider, also pioneering mobile calibration services and online tool tracking.

IN 2003 TWO BROTHERS who were both employed as representatives for a leading manufacturer of torque and bolting tools decided that it was time to launch a business of their own. "Andy and I had been working in this field for many years by then, and like anybody we'd come up with ideas of our own along the way," according to Tom Smith, CEO of Alltite, Inc. "So that's when we decided to join forces and see if our ideas were really as great as we thought they were."

The concept involved establishing Alltite as a provider of total bolting solutions, supplying a range of cutting-edge hydraulic torque tools, equipment, and accessories for sale or lease as well as offering training, program evaluation, and outsource services. Initially targeting the petrochemical industry—in addition to natural gas, power generation, and others—the company was soon involved in a number of wind farm projects. "What we found in all the markets we serve, but with wind in particular, is that there was a definite need for an all-inclusive quality program around bolting," Smith says. "Customers wanted someone to address all aspects of bolting such as tool sourcing, procurement, custom kitting, torque and tension training classes for wind technicians, and calibration equipment and services. The response was very positive, especially with our wind clients, and we've seen wind rise from about 5 percent of our annual revenues in 2004 to about 40 percent today. It's definitely our fastest-growing market sector."

The success of Alltite's approach led to advents such as MobileCal, a second company complementing the original model. "In 2005 we pioneered the concept of assembling a calibration lab in the back of a mobile laboratory and traveling to our customer's facilities or job sites to calibrate their torque wrenches, gauges, and other tools," Smith explains. "To further strengthen this approach we began a three-year process that resulted in accreditation by the American Association for Laboratory Accreditation, or A2LA, which assures customers that our quality system meets the requirements of ISO 17025 proficiency testing while also supporting the validity of our documentation and test results."

Not only does MobileCal provide convenience, it also improves the overall efficiency of its customer's operations. One example Smith shares involved a customer with 20 sites spread across the United States. MobileCal was able to organize its van routes in such a way that it had visited all the sites and calibrated the company's entire fleet of tools and equipment within four weeks of receiving the order. Records and certifications for each individual tool were also loaded into TorqueWare, Alltite's proprietary calibration software. The cloud-based portal makes all calibration records and certifications available online via secure customer login, also tracking each individual tool in terms of its physical location. Features include reminders of upcoming calibration dates for each tool, as well.

Joined together these capabilities power the company's Partner Program, which is a system-wide evaluation of a customer's operations with the goal of increasing efficiencies and providing quality assurance. Although the program can be tailored to meet any customer's needs, it generally involves an assessment by Alltite and MobileCal, taking inventory of a company's tools and equipment and providing an estimate of the site visits that will be required. Once approved, calibration is conducted according to schedule and the results entered into the TorqueWare system. All training, maintenance, and certification is then handled by Alltite and MobileCal as part of the package, with the customer enjoying access 24/7 online.

In addition to these services Alltite offers specialized wind kits, which it maintains and makes available for immediate shipment to its customer's job sites. As an alternative to actually purchasing the tools, Alltite offers a leasing program including automatic tooling upgrades as new technologies and designs become available, eliminating the well-known problem of tool obsolescence. In working with its customers to develop customized kits Smith says the company takes a "non brand-specific" approach, making them aware of the tools that are available and the pros and cons of each.

Smith says these programs were developed specifically for wind energy, but they've served as a model for similar systems offered to its customers in other markets. It is also harnessing its expertise in assisting community colleges to develop curricula for technician training and is a member of AWEA as well, contributing toward related standards development. "We're not just here to capitalize on an emerging market," he says, listing customer such as GE, Alstom, and Xcel Energy. "We see ourselves as a contributing member of the wind energy industry, and we will continue supporting its growth throughout North America."

ADVANCES IN BOLTING TECHNOLOGY

The i-Bolt ultrasonic fastener technology developed by Load Control Technologies allows the precise direct measurement of load in fasteners.

By Srinath Srinivasan

Srinath Srinivasan is a sales and marketing engineer at Load Control Technologies. Go online to www.loadct.com.

BOLTED JOINTS ARE ONE of the most common elements in construction and design, and yet they are frequently the root cause of expensive structural failures. For an industry as young and exciting as wind energy joint failures can mean not only the loss of several million dollars, but also a severe dent in its quest to achieve wider acceptance as a reliable and attractive source of energy.

Breakthrough innovations developed by Load Control Technologies (LCT) have been addressing these concerns in the industry. Conventionally, when engineers designed bolted joints they designed to load or clamping force, but thereafter assembly and inspection was purely guesswork based on torque measurement. The i-Bolt® ultrasonic fastener technology developed by LCT clears all these ambiguities. The technology allows precise direct measurement of load in fasteners. This is seen to be immensely useful for controlling the tightening process in production and subsequent inspection measurements, all with load accuracies 10 times better than conventional techniques. The end result is that engineers are now equipped to not only design to load, but also to assemble and inspect to load, with absolute confidence in accuracy.

UNDERSTANDING JOINT FAILURE

Most joint failures are not due to joint design or the fastener selection. More often they are the result of

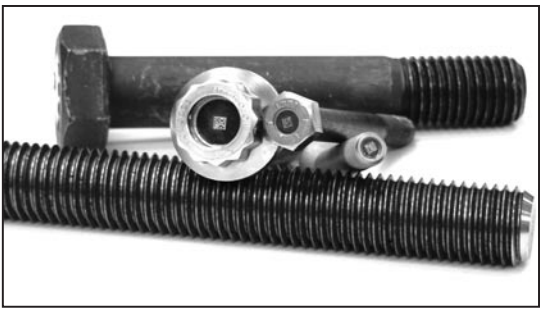

Fig. 1: i-Bolt technology equips the end users' fasteners with a low-cost permanent ultrasonic transducer at the top or the bottom of each bolt.

insufficient or inconsistent clamp load at assembly. Problems such as bolt fatigue or vibration loosening, which account for over 75 percent of all bolted joint failures, can usually be prevented by achieving and maintaining a correct level of clamp load in the joint. A variation in installed fastener clamp load of 30 percent is typical with tightening control methods based on the measurement of applied torque. With the i-Bolt technology end users are able to tighten fasteners directly to load with ± 3 percent typical accuracy using any kind of tool, including high speed impulse and impact wrenches. All assembly torque, yield, and friction issues are completely eliminated. At any time after assembly and during the life of the joint, the operator will also be able to inspect the residual load in each joint in less than two seconds with ± 5 percent and without disturbing the joint. The i-Bolt technology is already proven in other industries and has been adopted by companies like Boeing, Airbus, John Deere, and GM after extensively validating the technology and its benefits (fig. 1).

The i-Bolt technology takes the end users' fasteners and places a permanent ultrasonic transducer (only 50 microns thick) at the top or the bottom of each bolt. The transducer comprises of two layer: piezoelectric layer, which is the active element, and a metal electrode. Each transducer also has a 2D bar code laser etched on the surface, providing each fastener with unique traceability and a link to a database of assembly and inspection history. At no time during these processes is the form, fit, or function of these fasteners affected or changed. For load measurement an electrical pulse is applied to the transducer, which produces an acoustic wave that travels the length of the fastener and is reflected off the end and back to the transducer. The fastener elongates and the speed of this ultrasonic wave reduces with load, and the increase in time of flight of the acoustic wave provides an accurate measurement of load.

Unlike conventional ultrasonics, this technology doesn't require parallel surfaces and is not dependant on transducer attachment procedures. Each bolt type and joint is first ultrasonically qualified by LCT, which replicates the end user's joint, generates the ultrasonic parameters, and stores the ultrasonic signatures (including the zero load reading) of each individual bolt against their respective unique IDs in the transducer embedded 2D barcode. Once a joint/bolt type is qualified, it is so for the life of it. Bolts can be ordered indefinitely thereafter. The i-Bolts are ready to be used right away when the end users receive them. Moreover, the transducer is permanent and enables load inspections throughout the life of the joint at any time with near perfect repeatability and an accuracy of better than ±5 percent independent of the operator.

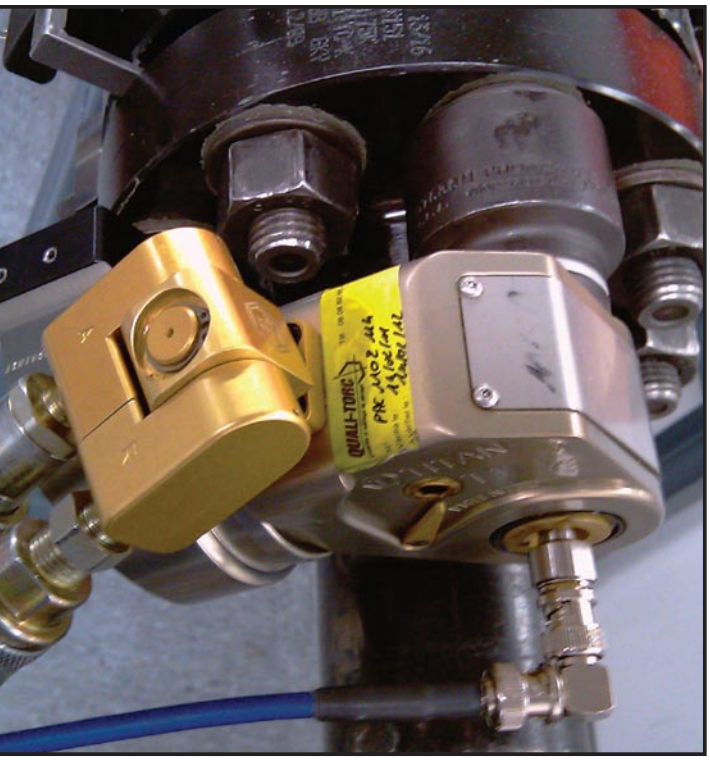

Fig. 2: Load controlled tightening using a hydraulic wrench for wind turbine bolt assembly.

SEAMLESS CONNECTIVITY

The i-Bolts also work seamlessly with assembly tools. All existing hand and powered production assembly tools, including low-cost impulse and impact tools, are easily adapted for precise load control. These tools are equipped with a single, inexpensive, spring-loaded contact pin in their respective drives. The LoadMaster® ultrasonic control electronics are connected to the tool or incorporated inside the housing of the tool itself. These electronics generate the transducer excitation pulse-echo time of flight measurements and translate them into precise load readings. Load readings are then read by the assembly tool controller as the fastener is being tightened. The tool controller now monitors and stops on the required load (instead of torque) with a 3 percent accuracy.

These tightening and inspection data are digitally recorded. During routine inspection, the fastener is identified through the 2D bar code. LoadMaster electronics retrieve the zero-load acoustic signature and zero-load reading. The load measurement is then displayed onscreen and is

Fig. 3: i-Bolt technology drastically reduces time, effort, and money compared to conventional inspection techniques.

automatically data logged in a maintenance database using a wireless link or directly to a PC using USB or Bluetooth as a permanent record of assembly and inspection history or in the form of excel spreadsheets for analysis.

Importantly, the technology allows inspection on a fastener to be completed in two seconds. To inspect 10 percent of all the bolts on a wind tower, it typically takes over six hours with two men working in tandem. If one bolt fails they test all the bolts in that particular wind tower, which amounts to over 120 man hours. Using i-Bolt technology, such a routine inspection of 10 percent of bolts can be completed by a single man in 30 minutes. These savings are in additional to assembly cost reductions during installation from the reduction in the number torquing operations.

With these breakthrough capabilities the technology has seen application and acceptance in petrochemical, aeronautical, construction, automotive, as well as other fastener-intensive industries. With the minimal capital investment required in manufacturing equipment, and with products that can be immensely cost saving, the technology has excited market leaders in all these industries. It is at an exciting point in the wind industry, with companies now adopting the technology.

SUMMARY

In conclusion, the technology is a big stride in quality assurance and preventive maintenance, as the end users can now measure load in the actual joint (without affecting it or changing it) to determine the installed loads achieved with their current tightening process. In addition, it provides traceability for each bolt. There is also the option for continuous load monitoring and the capability for real time field testing. Design engineers now have the potential of using smaller or fewer fasteners by tightening directly to load with i-Bolt. The ± 3 percent assembly accuracy allows them to utilize of the full strength of the fastener and verify they are achieving and maintaining that load in their joint designs throughout the life of the equipment.

TRANSFORMING OUTAGES INTO UPTIME

Is your wind turbine step-up transformer the weak link in the energy chain? Pacific Crest Transformers outlines what you need to know to increase revenue and reduce costs.

By Curt Collins

Curt Collins is vice president of sales and marketing at Pacific Crest Transformers. Go online to www.pacificcresttrans.com.

CONVERTING WIND ENERGY TO ELECTRICAL power is the fastest growing segment of the U.S. energy sector. Bolstered by available federal stimulus dollars there has been a virtual modern-day "land-rush" to develop wind farms. In the words of one industry leader, "If there is a site that has a viable wind profile, access to network connections, and access for delivery of materials and we don't develop it, someone else will."

This headlong rush to install more and more wind turbines has outstripped the usual developmental learning curve, in which new technologies mature by a process of trial and error, resulting in defining equipment that is suited for the job at hand. In this 21st century land rush, developers are often trading low initial costs for higher total costs of ownership to be shouldered later by the wind farm owners and operators. Nowhere is this more evident than with wind turbine generator (WTG) step-up transformers.

Historically the WTG transformer function has been handled by conventional, off the shelf distribution transformers. However, the relatively large numbers of recent failures has convinced many that WTG transformer designs must be substantially more robust. In fact, using conventional distribution transformers as a low cost solution is folly. In some cases site operators are even keeping a quantity of spare transformers at their wind farms so they

have spares on hand for the frequent outages caused by using standard distribution transformers where they simply do not belong. What a waste of capital!

The key WTG step-up transformer design issues that wind farm owners and developers should pay attention to include transformer loading, harmonics and non-sinusoidal loads, transformer sizing and voltage variation, and special requirements to withstand faults. The role of the WTG step-up transformer is critical, and its design must be carefully and thoughtfully analyzed and reevaluated. We need to move from equipment purchasing decisions based on lowest initial cost to solutions that will provide the best choice in terms of total cost of ownership, network stability, less downtime, and lost revenue from high maintenance issues. New transformer technology specially designed for the wind farm market should be considered carefully when making purchasing decisions.

TRANSFORMER LOADING

Wind turbines are highly dependant upon local wind and other climatic conditions, and their yearly average load factors can be as low as 35 percent. Most utilities in the past anticipated that operational loading would be about 50 percent. The relatively light loading of the WTG transformer introduces two unique and functionally significant problems that must be incorporated into WTG design.

The first issue is that the wind farm transformers' relatively low average load factors skew purchasing decisions and make older economic models inaccurate. When lightly loaded or idle the core losses become a more significant economic factor, while the coil or winding losses become less significant.

Previous purchasing decisions included an estimate of the transformer's amount of idle time. The overall evaluation looks at how much of the time the transformer is sitting idle and how much it will be running, and compares the ratio of these two. Those looking to apply this mode to wind farms must be much more cognizant of idle time; the typically used price evaluation formula does not apply to this scenario.

For example, National Electrical Manufacturers Association (NEMA) TP 1-2002 (Guide for Determining Energy Efficiency for Distribution Transformers) and DOE efficiencies are not modeled for the operational scenario where average loading is near 30-35 percent. Wind farm developers should be extremely cautious about applying these standards when calculating the total cost of ownership for WTG transformers.

The second problem is that the WTG transformer is subjected to frequent thermal cycling as a function of varying turbine loads. This causes repeated thermal stress on the winding, clamping structure, seals, and gaskets. The situation is analogous to breaking a wire by bending it back and forth until it breaks. The metal fatigue, heat, and stress weaken the wire and cause it to break. The same is true of electrical connections that have to withstand repeated thermal cycling, stress, and varying loads.

Repeated thermal cycling causes nitrogen gas to be absorbed into the hot oil and then released as the oil cools, forming bubbles within the oil that can migrate into the insulation and windings to create hot spots and partial discharges that can damage insulation. The thermal cycling can also cause accelerated aging of internal and external electrical connections.

HARMONICS AND NON-SINUSOIDAL LOADS

WTG transformers are switched with solid-state controls to limit the inrush currents. While potentially aiding in the initial energization, these same electronic controls contribute damaging harmonic voltages that, when coupled with the non-sinusoidal wave forms from the turbines,

FEATURE	BENEFIT
Mitered, cruciform core w/ circular winding	Circular windings spread the radial forces evenly in 360.
Starts round, stays round	Deformation in the coils can expose the layer-to-layer insulation, causing premature breakdown (including combustible gas formation) and ultimately, flash-over and transformer failure.
Coil end blocking by means of pressure plates	The pressure plates, made of a multi-layered product specifically designed for transformers, contain the axial forces exerted during a fault condition. These forces, if not contained, can cause the "telescoping" of the coils, again shortening the life of the transformer.
Proprietary cooling design	Pressure plate design channels the cooling fluid flow, in a laminar path, through ducts throughout the coils without sacrificing the containment of axial forces. The result effectively shortens the path that heat, generated within the core and coils, must take to be reach the cooling fluid.
Cooling flow around each phase	Element design allows for cooling fluid flow to pass through between phases, again shortening the path heat must travel to the fluid. This eliminates the hot spots which are trapped in a wound core design.
Engineered solution	Designed to meet the unique requirements of the individual farm, its turbine type and associated electrical components (harmonic contribution and load profile).

Fig. 1: Wind Turbine Features and Benefits

cannot be ignored from a heating point of view.

Normal voltage is alternating at 60 cycles per second. If the transformer operates at other voltages, the voltage peaks will not line up and you will not get the amplification you would achieve when frequencies line up. The transformer tries to pass the voltage it sees through the circuit and causes extra loading. All the electronics used today send spikes on the line, and each time a frequency disturbance goes back to the transformer it must be able to handle the higher loading it sees.

When a rectifier/chopper system (the electronic controller used in wind turbines) is used, the WTG transformer must be designed for harmonics similar to rectifier transformers. These are "dirty" from a harmonics point of view, meaning they may contain high frequencies that the wind farm owner does not want to pass onto the utility power's grid because it will affect other equipment.

If this happens it can result in a protective equipment fault, causing transmission grid equipment to protect itself against faults by shutting down. The WTG must be able to take the additional loading into consideration and provide electrostatic shields to prevent the transfer of harmonic frequencies between the primary and secondary windings. It must be able to handle the energy and not transmit it to the grid.

TRANSFORMER SIZING AND VOLTAGE VARIATION

Because of the high upfront costs, no over-voltage capacity is designed in to a WTG transformer to overcome the frequent voltage fluctuations inherent with wind turbines. WTG transformers are usually designed so the transformer voltage exactly matches the wind turbine's output voltage. There is a one-to-one correspondence between transformer and turbine, and each turbine produces a fixed amount of energy, so future growth is a known fact.

At the same time, the generator output current is monitored at millisecond intervals and the operational limits allow up to 5 percent over-current for 10 seconds before the generator is taken off the system. Since the WTG transformer is designed to match the generator output with no overload sizing, its design must be uniquely robust to function without the extra capacity.

REQUIREMENT TO WITHSTAND FAULT CURRENTS

Typically, conventional distribution transformers, power transformers, and other types of step-up transformers will "drop out" when subjected to a fault. Once the fault has cleared, the distribution transformer is brought back online. To maintain network stability, wind turbine generators are not allowed to disconnect from the system when there are network disturbances, except within certain guidelines developed for generating plants. They must be able to stay on the line through the fault and must be mechanically, electrically, and thermally able to handle the fault. This is called "fault ride-through."

The length of time the generator is required to stay online can vary. During this time the generator will continue to deliver an abnormally low voltage to the WTG transformer. For example, during faults the transformer may be required to carry as low as 15 percent rated voltage for a few cycles and then ramp back up to full volts just a few seconds after fault clearing. The WTG transformer must be ruggedly designed so it can withstand full short circuit current during the initial few cycles when the maximum mechanical forces are exerted upon the WTG transformer windings.

WTG STEP-UP TRANSFORMER CHECKLIST

The role of WTG transformers in today's wind generation scheme is unique, so its design must be equally unique and robust. Don't trade long term reliability and lower total cost of ownership for low initial cost. Make sure you consider these specific factors to ensure that your wind turbine step-up transformer is a strong link in the chain.

- The WTG step-up transformer should have enough cooling to handle thermal events. Since heat travels layer to layer, minimize the distances to cool it most efficiently.
- Brace the WTG mechanically to withstand events. Axial forces, which drive the transformer windings to telescope and come apart, are best maintained with coiled end blocking. Radial force, which make transformer windings expand outwardly, escaping each other as the electro magnetic field becomes polarized and pushes the winding apart, are best maintained with round or circular shaped coils so the forces can spread forces evenly at 360 degrees.
- Minimize core losses due to downtime. But proactively consider cost and construction tradeoffs associated with decreasing core losses.
- When purchasing a WTG step-up transformer, make sure you factor in how reliability affects the total cost of ownership. Wind farm turbines are unique because they are ganged together and dependent upon each other. Say one transformer fails, for example, with a loss of revenue of about $1,000 per day. It may take two or even three days to replace the transformer, and in the meantime, the faulty generator may take down 10 to 14 other generators, not allowing them to produce. So that loss of $1,000 of revenue could turn into $30,000 in lost revenue, plus the cost of another transformer, construction labor, and crane expenses.

NEW WTG TRANSFORMERS FIT THE BILL

Pacific Crest Transformers, a leader in the design and construction of liquid-filled distribution transformers, has developed a wind turbine generator step-up transformer specially designed for reliability, given the factors discussed here. It features an innovative design that includes round coils, a cruciform, mitered core with heavy-duty clamping and a proprietary pressure plate design, as well as a premium no-load tap changer. Figure 1 shows the design features that provide the needed reliability.

The PCT design features circular windings with coolant flow ducts throughout the coils, which spread the radial and axial forces evenly over their circumference, eliminating hot spots that lead to premature breakdown and ultimately to transformer failure. Coil end blocking with heavy duty 3 gauge steel bracing and proprietary pressure plates contains the axial forces exerted during a fault condition. These forces can cause telescoping of the coils, shortening transformer life.

The WTSU has a unique cooling system, effectively shortening the path that heat generated within the core and coils must take to reach the cooling fluid. It also features a tap changer with silver-plated contacts for long life and reliable operation.

PROTECTING WIND ENERGY INVESTMENTS

Wind developers should look for an insurance carrier that can provide protection from risk through all stages of wind farm development and operation, according to Travelers.

By Lauren Berry

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IT IS NO SECRET THAT THE WIND energy industry in the United States has experienced strong growth in recent years as one of the most popular renewable power sources. In fact, according to American Wind Energy Association (AWEA), the U.S. wind industry has added over 35 percent of all the new power generating capacity over the last four years. This is second only to natural gas. As new developers enter this growing space, it is important to consider the variety of risks they are exposed to during the process of building and operating a wind farm.

In addition to managing their risk exposures, developers need to ensure that they have a solid understanding of the various types of insurance coverages that will help protect their investment. Whether the wind farm will have multiple turbines and sites, or a single turbine is added to a commercial location, a developer should look for an insurance carrier that can provide coverage to help them manage risk throughout the lifecycle of the wind farm operation.

Developing and running a successful wind farm requires attention to detail, and every step from site selection to operations and maintenance brings a new challenge. Through the multi-step process of setting up a wind farm there are risk management best practices and proper coverages that develop-

ers should consider to minimize exposures while building a successful operation.

SITE SELECTION AND LAND ASSESSMENT

When selecting a site, conducting a feasibility study is a critical first step for developers to better understand the potential energy output that could be produced at a given location. To help make these assessments, meteorological (met) towers are installed on the land for extended periods, often one to two years, in order to assess the site's wind resource.

The identification and management of risk surrounding the use of these valuable assets is paramount as the project moves forward. Met towers may be subject to a variety of exposures including weather-related elements (wind, ice and snow, lightning) or fire, collapse, and vandalism. Insurance protection, such as a scheduled property floater or a builder's risk or installation policy, can help protect owners and ensure that towers are adequately covered should damage occur.

In addition to reviewing the exposures for the physical property, the potential liability exposures should be analyzed. Updates to insurance coverage may be needed depending on how the existing property will be modified for the operations of a wind farm. Once a site is purchased or leased developers need to be aware of potential land exposures, whether it be vacant land set aside for the wind farm construction or property where a wind turbine may be located in close proximity to other structures or dwellings. An insurance agent who is well versed in providing coverage for wind farms, and understands exposures associated with wind turbines, can be a great resource for more detailed information on issues associated with general liability coverage, which can protect owners in case people are injured on site or when non-owned property is damaged. As the site is being assessed for wind energy potential, a developer should also consider other factors in site selection:

- An environmental analysis of the proposed location helps determine how the development and operation of a wind farm may impact the environment such as noise, wildlife, plants and soil, endangered species, and the flying patterns for migratory birds.
- Flood and earthquake potential should be analyzed for the site under consideration. Building a farm in a designated flood zone or an area prone to earthquakes can have a long-term significant effect on turbines.
- The accessibility of the site should be considered. Farms are often located in remote areas or even mountainous terrain, so owners and operators need to ensure that adequate roadway infrastructure is in place to get heavy equipment and supplies to the project site, and to provide accessibility for workers and emergency responders.

CONTRACTUAL REQUIREMENTS

After site selection and land assessment has occurred, a myriad of contracts should be in place before construction begins, starting with the construction contract. Another document important to consider is the Power Purchase Agreement, or PPA, which is the agreement between the developer/owner and an energy buyer, such as a public utility. The PPA outlines expectations about the

price and production for the energy being sold.

In addition to detailing what the buyer will pay for the promised production, the contract also contains other important information such as insurance coverage requirements, and may have clauses limiting the liability of both parties or even a waiver of subrogation. Assignment of financial responsibility for differing types of required insurance coverage and other clauses are important to consider, as each contract is unique. How the contract is structured may impact long-term revenue.

Developers should be aware of other contracts as well, such as an Interconnection Agreement, which specifies the terms and conditions under which the wind farm's system can be connected to the utility grid. Financing agreements are often contingent upon the successful placement of insurance and bonds, so management oversight in this area is critical. It's also important to involve your legal counsel in all your contract matters.

SECURING PERMITS

Permitting is a vital step associated with installing wind turbines. This process can be complicated and may affect timing, location, and costs of the project. This step often moves forward in earnest when it is clear the environmental review process is moving ahead favorably. Local zoning ordinances vary greatly and change as this industry evolves. Be aware of local zoning ordinances in order to secure permitting, from assessments through construction and operation.

TURBINE PROCUREMENT

Securing the type of turbines most appropriate for the site is the next step where developers should consider their potential exposures. The turbine sales agreement will outline contractual requirements, and the experience of all parties involved should be reviewed. For example, when selecting a manufacturer, ensure they have a strong track record. Working with manufacturers that meet and exceed industry standards can positively impact the reliability and life of the equipment as well as reduce future risks. Additionally, consider the replacement time and availability of component parts along with the ability to get the parts to the job site.

The transportation of wind turbines adds another layer of complexity to the process of setting up a wind farm. Due to the enormity of the turbines—including the nacelle, blades and tower sections—transporting them can be a logistical challenge. A developer should ensure proper protection is in place to protect against potential damage to the turbine or other property during the transportation process. Work with shippers who are experienced in specialized hauling, and wind energy in particular, as they should understand the challenges associated with moving this type of cargo. Since components of turbines may come from overseas, developers need to be actively involved with their insurance agent to ensure they have the property and casualty coverage in place both for transporting turbines and their components stateside and overseas.

CONSTRUCTION CONTRACTING

One of the most difficult and dangerous elements of wind farm development is the installation of the towers and turbines. Developers should work closely with construction contractors at the outset to make sure the appropriate risk management processes and procedures are in place. The relationship with an experienced general contractor with a positive reputation for safety management and education of employees and sub-contractors is critical.

As construction starts to move ahead, this is another good point in the process for developers to again review their insurance, contractual, and bonding requirements, and work closely with an agent who understands the best coverages, risk management, and claims services to meet the needs of the project. Complex projects like this may need additional coverages for builder's risk, workers compensation, general liability, auto liability, and an umbrella policy, among others, as the farm is being built. Reviewing insurance protection throughout wind farm construction will serve to help mitigate and protect against a multitude of potential risks.

OPERATIONS AND MAINTENANCE

While construction of the farm is underway, wind farm developers will also look to ensure that the operations and maintenance (O&M) contracts and plans are under development. These contracts play a large role in ensuring that the output and anticipated life of the turbine meet expectations. Protection of the assets and performance of routine and planned maintenance are primary functions of the O&M team. The developer and owner need to consider how local conditions can affect the turbines. Gearbox components, tower metal, fasteners, and blades are subject to wear and tear, and this—along with other signs of fatigue—can make a significant difference in the safety and production of each turbine.

PROTECTING THE BUSINESS

Now that the wind farm is nearing a fully operational state, wind farm developers should look to ensure they have business interruption coverage in place in the event that the farm may have to shutter its operations, even temporarily. For example, wind farm developers may take advantage of feder-

al and tax incentives to help make the wind farm's operation financially manageable. If business is interrupted due to a fire or even a major weather-related event, the cash flows from these grants could also cease, which could adversely affect the business. Business interruption coverage helps with the loss of income during that time frame. Purchasing insurance to protect the business against the event of business interruption can provide the developer much needed financial security.

CHOOSING THE BEST COVERAGE

A wide range of insurance products and services are available to wind farm developers. Here are some guidelines that developers can follow to help when making insurance purchases for their unique needs:

- *Lifecycle coverage:* Can your insurer provide coverage as the farm evolves through each stage? Having one insurer who can cover all aspects of wind farm development can help simplify and strengthen the insurance process. Using different insurers could leave some grey areas or even gaps in coverage.
- *Growing with the business:* Wind farm developers may seek new opportunities to expand their business operations, whether it is to increase power output at a given location or start new construction projects. Will your insurer cover wind farms of all sizes so that the relationship can grow as the business expands?
- *Reliable experts:* Working with an insurer with expertise in the renewable energy industry can have significant pay-offs for wind farm developers. This encompasses having underwriters who can assess risk accurately based on their extensive industry knowledge and provide appropriate coverage for competitive premiums, risk control advisors who can deliver guidance on best practices and claim professionals who understand the contractual language and industry processes to help mitigate losses.

As the shift to renewable energy and wind farms continues to gain momentum, those looking to join the growing industry will be faced with many decisions. Among the most important is the plan a new developer creates to minimize exposure and ensure that they are well protected from unexpected loss by having the right contracts and insurance coverages in place. Working with an informed insurance agent and insurance carrier with deep knowledge of the renewable energy market can help their business grow and prosper.

FLEXING CABLE FOR WIND APPLICATIONS

Cable construction and test data should be evaluated prior to being selected for any wind application. The experts with Alpha Wire explain.

Dr. Lu Li is product engineer, Dave Watson is director of engineering and QA, Chet Socha is senior product engineer, and Kristen Berard is applications engineer at Alpha Wire. Learn more at www.alphawire.com.

AS CONVENTIONAL ENERGY SOURCES—namely oil, gas, and coal—are increasingly limited in their respective quantities, many countries are encouraging the development of renewable energies. Wind energy, already a well-developed technology, is quickly becoming the most attractive renewable energy source. Cables used in the wind energy industry are facing challenges caused by the harsh environments where the wind can be harnessed most efficiently. The current status of the wind power industry is introduced herein, as well as the performance, requirements, and testing procedures of cables used in wind turbines.

INTRODUCTION

There has been increasing interest in renewable energy due to conventional energy resources being limited while demand still increases. Numerous types of renewable energy such as hydropower, wind power, solar power, geothermal power, tidal and ocean wave power, and biogas power have been emerging for decades. Although these renewable energies only cover a small portion of the entire energy demand, the promising future of these new energy sources is recognized globally.

In addition to the dwindling amounts of conventional energy sources, another factor accentuating the attractiveness of renewable energy is the pollution caused by fossil

fuel power plants. As an alternative to fossil fuels wind energy is plentiful, renewable, widely distributed, clean, and produces no greenhouse gas emissions during operation. At the end of 2009 worldwide nameplate capacity of wind-powered generators was 159.2 GW[1]. Energy production was 340 TWh, which is approximately 2 percent of worldwide electricity usage [1][2] and has doubled in the past three years.

Regarding the existing wind turbine maintenance and new wind farm construction, engineers and designers meet the inevitable situation of having to choose the correct cable for such applications. For example, inside the wind turbine nacelle continuous flexing control and data cables should be used, while torsional flexing cable should be used within the wind turbine tower. In addition to the flexibility requirement thermal resistance, abrasion resistance, and resistance to oil and other chemicals should be considered. The complexity of cable selection could easily lead to a wrong decision and result in unnecessary downtime and costly maintenance.

CABLE REQUIREMENTS FOR WIND APPLICATIONS

Wind farms are generally located in harsh environments with extreme weather conditions including high winds, ultraviolet light, and salt spray. Because of this the performance of the cables used in wind power applications is arguably more critical than that of other applications. The turbine's moving parts also add to the already heightened importance of proper cable selection.

Premium-grade power cables, data and control cables, and communication cables need to be considered for existing wind farm maintenance and new, large-scale wind farm development to determine the interconnection quality for the power grid and communication system. The amount of cable needed for just one wind generator is not quite as minimal as one might imagine. For example, a 90m high 1.25MW wind generator requires approximately 1km power cable. As such, 40km cable would be considered necessary for a wind farm with 50MW capacity.

Wind generators work in tough environments that typically feature a wide temperature range (around -40° C to 50° C) and extremely large amounts of exposure to UV radiation. Therefore, the specified cable needs to be able to withstand -40° C and ultraviolet light for the desired longevity. For the moving parts of the wind turbine, the cable should have good torsional and bending flexibility with a small bend radius. The cable also needs to be resistant to fuel, coolant, oil, corrosive chemicals, and abrasion. Should the wind farm reside close to the ocean or offshore, the cable must also be saltwater resistant. In addition to the aforementioned requirements, flame retardancy is also required due to safety considerations. In certain cases extra features such as low smoke, zero halogen (LSZH) materials, and EMI protection may also be required. Taking all this into account, cable used in a wind power application should generally meet the following criteria.

Conductor: To maximize flexibility, it is recommended that design engineers specify annealed soft copper conductors with high strand counts, with a short concentric-lay construction for bending flexing applications and a long concentric-lay construction for torsion flexing applications. For conductors larger than 6mm2 (10 AWG), a rope-lay construction is required.

Insulation: To increase flexibility in low temperatures, thermoplastic elastomer (TPE), ethylene propylene rubber (EPR, a type of EPM or EPDM), or silicone rubber (SiR) are common choices for insulation material to resist ozone corrosion and aging due to heat. PVC/nylon insulation is also widely used due to its high dielectric strength.

Jacket: Cable jackets may be thermosetting compounds such as chlorinated polyethylene (CPE), polychloroprene

(neoprene), chlorosulfonated polyethylene (CSPE) synthetic rubber (SR), or thermoplastic compounds such as TPE, TPE-PVC alloys, and polyurethane (TPU). These materials are oil-, fuel-, and solvent-resistant with superior flexibility under low temperatures. Such properties make them ideal jacket materials for wind power cables.

It should be noted that cable structure is also a considerable determinant the cable's flexibility. Symmetric conductor design with a balanced structure will typically lead to a high degree of flexibility. Even if a cable is built following these general guidelines, full testing is strongly recommended to simulate the "real world" application.

CABLE TEST METHOD AND PROCEDURE

Depending on the direction of the wind, the turbine angle needs to be adjusted by the yaw drive. The power, control, and communication cables will either bend along the horizontal axis or rotate along the vertical axis. Torsional flexing is more severe and requires greater attention. Although currently there is no such standard or regulation for torsional flexing, end users typically prefer that the cables are tested by some means before being put into practice. The following is a common test method adopted by an end user in the cable industry.

Torsion stress test of a single cable under low temperature (-40° C): A 10m vertical suspended cable sample is fixed at top end; fasten the bottom end to a rotating mechanism. First, twist the cable clockwise four turns (+1440°) and then untwist counterclockwise four turns back to its original position. Next, twist the cable counterclockwise four turns (-1440°) and then untwist clockwise four turns back to its original position. Repeat this procedure for 5,000 complete cycles to simulate 20 years use. The cable shall pass the test if there is no breakdown under 2.5 U0 after five minutes and no cracks shown on jacket. Note: U0 is 600, 1000, or 2000 V according to the cable's voltage rating. For torsion stress test of a bundle of cables the procedure is the same, but for a cable bundle.

STANDARDS FOR WIND POWER CABLE

Currently no dedicated standard exists for cables in wind power applications. Many cable manufacturers follow IEC 60228 Class 5 or 6 (similar to DIN VDE 0295 Class 5 or 6, HD 383, GB/T 3956 Class 5 or 6) to use plain or metal-coated annealed stranded copper as the wind power cable conductor to achieve the needed flexibility. Interestingly, the IEC 60228 only specifies the nominal cross-sectional areas of the conductor and the number and size of wires in the conductor for electric power cables. This gives cable manufacturers a high degree of autonomy, often resulting in poor cable performance even though the cable meets the IEC 60228 Class 5 or 6 requirements. Conversely, UL 62—which refers to several ASTM standards—specifies not only the size and number of strands of the conductor, but also the conductor constructions such as concentric lay stranded, rope lay stranded, and bunch stranded con-

ductor constructions which are all critical to the cable flexing characteristic.

For the insulation and jacket many manufacturers follow DIN VDE 0207-20 and DIN VDE 0207-21. HD 22.1, HD 22.4, UL 44, and UL 62 are also used as general standards for cable production. Other standards, such as UL 758, UL 1581, UL 1277, UL 2277, and IEC 60332, etc., are often used to support extra features like the Wind Turbine Tray Cable (WTTC) and flammability ratings.

As European countries began developing cables for the wind energy market before North America, many European standards are currently adopted by cable manufacturers. Nevertheless, UL standards as a counterpart show equivalent and, in some cases, tighter requirements pertaining to wind energy applications.

SUCCESSFUL APPLICATION

MLS Electrosystems is a global leader in the development, design, manufacture, distribution, and support of custom electric servo pitch systems for the wind turbine industry. MLS was created in 2000 when SIPCO Mechanical, R2J Technologies, and Matric came together and merged their market expertise and knowledge to focus on the servo control industry. MLS made many key improvements to the existing servo pitch control motor product line through a great deal of research and development. As a result, their design is now one of the best in the wind turbine industry.

MLS had been using plain wire for emergency power on a pitch servo motor located within the wind turbine. However, they were in need of a cable that could withstand temperatures as low as -40° C since the wire they were using was not holding up in the extreme environments that it was subjected to and were continually failing. As a complete solution, MLS chose Alpha Wire's Xtra-Guard® 4 performance cable for its pitch servo motor. Not only does Xtra-Guard 4 withstand extremely high and low temperatures (-50° C to + 125° C), it is also known for its extremely high resistance to oils, chemicals, solvents, and fuels, all of which would benefit this outside application.

CONCLUSIONS

This technical paper introduces the current status of cable applications for the wind energy industry. The special requirements for wind power cables and their detailed construction and composition are summarized. A commonly recognized test method for cable torsional flexibility is also introduced. It is suggested by the authors that the cable construction and test data should be evaluated prior to selecting the cable for any existing wind farm maintenance and future wind energy facility constructions.

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BATTLING EXPOSURE WITH BLADE COATINGS

Wind turbine blades are exposed to the sun's rays, temperature extremes, lightning strikes, and airborne particulate matter such as sand and dust. BladeRep coatings can help.

By Jeff Grandgenett

Jeff Grandgenett is with Mankiewicz Coatings, LLC. Call (843) 654-7755, e-mail info-usa@mankiewicz.com, or go to www.bladerep.com.

SMOOTH SURFACES ARE CRITICAL to the performance of wind turbine blades. ALEXIT® BladeRep is an advanced blade coatings solution that maintains smooth turbine blade surfaces for optimal performance and efficiency.

For more than a decade the BladeRep system has proved to perform effectively in all conditions, ranging from challenging to harsh. These innovative coatings meet aesthetic requirements as well as OEM small-to-medium blade specifications for high quality and durable products.

BACKGROUND

For 100 years BladeRep's Hamburg, Germany-based parent company Mankiewicz Gebr. & Co. has led in the development of superior coatings products. From humble beginnings painting horse and buggy coaches to today's highly technical applications on machinery, automobile interiors, commercial airliners, and super yachts, Mankiewicz's sense of environmental responsibility is at the heart of the company's success. In fact, environmental protection has been a corporate edict long before climate concerns arose. Our large R&D department devel-

ops eco-friendly, high-performance products with the best interests of the end user as the primary objective. Mankiewicz's reputation has attracted an international team of coatings authorities that work with R&D to provide superior coatings for the wind-power market.

This revolutionary system is formulated to meet or exceed the ever-increasing expectations and environmental regulations of the global market, both current and future. The selection of raw materials found in BladeRep formulas is based on analyses of long-term availability and environmental compliance, and our team of over 120 chemists continues to ensure BladeRep continues providing innovative global coatings solution.

Based on successes across a multitude of industrial applications, it was a natural progression for Mankiewicz to extend its coatings expertise with the wind-power market. The BladeRep team started with Mankiewicz's proven ability to match groundbreaking formulations with varying engineering needs in order to protect a wide range of equipment and machinery. Our chemists tailored these formulas for wind power use by incorporating recent advances in resin technology with aviation systems developments, which demand both exceedingly durable coatings and stringent safety and environmental compliance.

TAILORED SYSTEMS

The ALEXIT BladeRep coatings system consists of profile filler, pore filler, leading edge protection, and topcoat to efficiently protect and maintain blades from the inherent harsh and varied conditions they are subjected to. All BladeRep products are two-component and polyurethane-based. Once applied a long lasting, durable, and streamlined surface promotes cost-effective operation with an improved lifespan.

BladeRep products are well matched to make up a complete repair system that is GL certified for performance and reliability. Available in a variety of user-friendly packaging and quan tities for ease of use, greater cost efficiency is also achieved with less waste. These products are also versatile and can be used individually or as a complete resurfacing system. Each product is packaged for repairs and OEM applications of any magnitude, from a single damaged blade to a new wind farm. BladeRep products are also formulated for easy mixing and

application, with improved drying time and exceptional cured strength. All products meet or exceed OEM standards and are specifically designed for turbine blade applications that are meant to last. Products that can be used alone or as part of the complete system include:

Profile Filler 3: Used for filling major imperfections caused by weather or object penetration, this is a solvent-free, two-component polyurethane filler designed to be used for filling and fairing on glass reinforced substrates. This non-porous filler cures into an easily sanded surface and is ideal for repairing non-structure threatening cracks, pock marks, hail inclusions, or other deformations caused by flying objects or debris.

Pore Filler 6: Used for filling smaller pinhole size surface imperfections, BladeRep Pore Filler 6 is a solvent-free, two-component polyurethane filler designed to seal any surface to achieve a defect-free, smooth surface prior to applying LEP 9 or Topcoat 12 on glass reinforced substrates. Pore Filler 6 cures to a surface that is easy to sand and is ready for finish coating.

LEP 9: Used as a finishing product specifically designed to protect leading edge areas where a coating with excellent abrasion and erosion re-

sistance is required, this two-component, solvent-free polyurethane product has superior elasticity and flexibility for long-term leading edge protection. These "stretch" properties help distribute the kinetic energy of a variety of environmental conditions such as rain, sleet, snow, and pelting sand, thereby reducing blade erosion and extending the life of the blade.

Adhering to our market-responsive ethos, a built-in BladeRep Maintenance Service Indicator (MSI) was developed from major wind-farm owner and applicator feedback. MSI is a system within the LEP 9 system, where a variety of application colors—red, white, gray, and black—helps to show the wear visible from down tower so you know where you are in your blade life expectancy. By visually identifying erosion, you can now be proactive with blade maintenance to avoid costly repairs after the fact.

Topcoat 12: Used for additional protection as a final topcoat to permanently seal and finish blade surfaces and provide exceptional durability, Topcoat 12 is formulated specifically for coating blades where a superior product with chemical, UV, abrasion, and mechanical resistance is required. This two-component polyurethane topcoat provides applicators with the ideal product for extending blade life and may be applied over all BladeRep products or any properly prepared surface. Available in all color shades, Topcoat 12 can be easily matched to original equipment manufacturer colors as well.

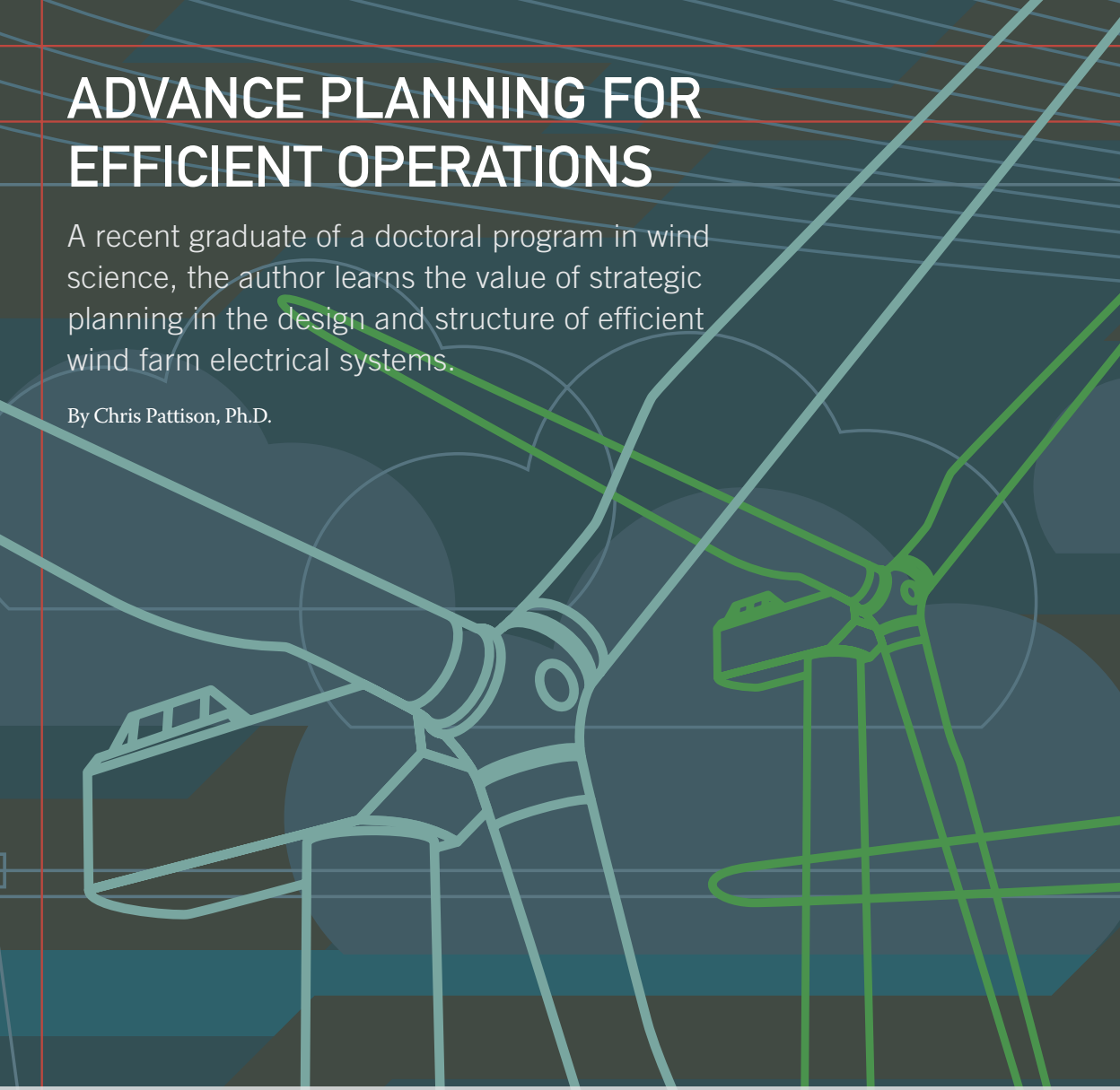
CONCLUSION

By following simple application and maintenance procedures you will add to the efficiency, reliability, and economy of any wind-power system. Perhaps the best reason to choose BladeRep, however, is the service our business model offers. The BladeRep team doesn't punch a clock, and our coatings experts hail from a wide range of technical backgrounds dealing with the harshest elements on earth. They are in the field ready to solve any challenges, and in the lab and on the loading dock to ensure that your shipment goes out on time and as ordered. To address increasing demand we have more than doubled the members of our wind-power support team over the last five years, at the same time establishing an easily accessible global network of product distributors.

ADVANCE PLANNING FOR EFFICIENT OPERATIONS

A recent graduate of a doctoral program in wind science, the author learns the value of strategic planning in the design and structure of efficient wind farm electrical systems.

By Chris Pattison, Ph.D.



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SHORTLY BEFORE RECEIVING MY DOCTORATE in wind science and engineering from Texas Tech University I began working for an electrical engineering firm, taking on the responsibility of wind energy development. In the last few months I have listened to and discussed comments about wind energy from various engineers in their respective departments. All seemed to be on the same topic; that wind developers wait until the last minute to do several things. Wind developers seem to take great care in the turbines they select and then rush the electrical design for the transmission, substation, and collection systems. This rush causes less than optimal economic design in order to meet project deadlines and makes for a less-efficient operating wind farm. Money spent up front is not lost, but affects the end product considerably. Here is what I have learned in the last few months at SGS Engineering.

After a wind developer has wind data and leased area, the actual development process begins. At this time early planning with an electrical engineering firm can be quite advantageous to the profitability of the wind farm. Not only can the engineering firm help with the interconnect agreement and making early decisions about metering, but their expertise can be used to the fullest in the com-

plete design process. Because of decisions made without the aid of an electrical engineering company, several currently operating wind farms are now contacting them to fix mistakes made previously at substantial labor cost and downtime as conductors and equipment are replaced. An under-designed electrical collection (EC) system can cost a wind developer significantly in EC losses, reducing revenue over its entire life.

For new wind farms, every dollar saved during the early stages of development helps the project get off the ground. In the current economic state, power purchase agreements (PPAs) are difficult to obtain at a high enough price for viability, and again, proper review and evaluation of the system requirements in the early stages can be crucial to a successful long-term project.

Early decision making areas may include some of the following: the SCADA system (software and compatibility with the equipment), electrical collection system (overhead vs. underground), cost of losses, bid documents, substations (expansion and redundancy), and transmission. By contacting an electrical engineering company in advance of purchasing turbines, the design costs can be controlled and efficiencies improved as all aspects of the wind farm are considered according to terrain, local politics, costs, taxes, efficiency, and turbine specifications. The largest area of savings is the electrical collection system, as it will benefit the wind farm for 20 years or more.

ELECTRICAL COLLECTION SYSTEM DESIGN

Oftentimes a meteorologist places turbines for a project according to the local wind resource. Dwellings, roads, setbacks, and geographic features are also taken into account as the turbines are micro-sited. However, this frequently leads to a disjointed layout for electrical collection system leading to increased costs and higher losses. I have witnessed where a wind developer has come with a desired layout and was adamant about following it. After designing the EC to the layout the cost of the collection system became prohibitive, as it had to reach a hodgepodge of turbines placed at irregular intervals and remote locations due to the land-lease agreements.

When someone with wind energy understanding and electrical engineering know-how is given the freedom to micro-site the turbines, as is the case at SGS Engineering, the EC can be designed appropriately. With the ability to move one or two turbines to more conducive locations, hundreds of thousands of dollars may be saved. This can quickly add to enormous savings for a large, complete wind farm. By allowing knowledgeable engineers from a multidiscipline engineering firm to place the turbines, the EC system can be optimized, as well as the number and length of access roads needed for transportation and construction can be reduced. This, too, is another source of significant savings.

When designing the electrical collection, high resolution images can be easily imported into the engineering software enabling an engineer to maintain proper turbine spacing, setback distances from roads and homes, and avoiding terrain features that either affects wind flow or the degradation of buried EC conductors.

To better optimize the EC system, an electrical engineering economic model is used for determining conductor type and sizing. The model is built by taking into account the interest on the wind farm's loan, local tax rates, depreciation, line-load factors, individual line-loss factors, and the estimated PPA. From this model the most economic, long-term conductor size can be easily determined based on the individual distances between turbines throughout the EC system. Built around these accurately supplied values it may be more economical to use a 4/0 conductor over 1/0 due to the value of the produced energy and the losses on that line over the life of the wind farm. For example, a 100-turbine wind farm with improperly sized conductors is experiencing 4 percent EC losses; four of the turbines are essentially used to offset the losses, and therefore produce no revenue. Analysis may direct the selection of conductors that would reduce losses to less than ½ percent.

Keeping conductor size changes to a minimum allows for ease in ordering and facilitates cheaper per-unit costs. Instead of ordering two miles each of 1/0, 4/0, 500, and 1000 MCM underground conductors, it may be more cost effective due to losses to order four miles of 4/0 and four miles of 1000 MCM conductors. It also may be more economical to place overhead lines between two rows of turbines than to have two or more underground circuits. This allows for more energy to enter the EC substation on fewer circuits, again, reducing costs. "Economic sizing of conductors allows more electrical product to be sold and greater revenue received," according to SGS planning department head Mike Smith. Being able to place the EC substation in the most advantageous location is another skill of an electrical engineer. By moving a substation's location within a wind farm, losses can be minimized with the reduction in lengths of underground or overhead conductors, maximizing output and improving revenue.

SUBSTATION DESIGN

Additional savings can be found when proper planning precedes the designing of substations. Not only is substation siting paramount to power delivery, but rushed work provides little time for review and increases opportunities for poor design. Substation equipment needs to be competitively bid. Availability isn't necessarily better. "Availability and fast turnaround seems to be the norm in wind farm construction," says Monte Wolgamott, partner and project manager of substation design at SGS. "We have seen wind developers save a few thousand dollars per pad-mount transformer for the turbines and then lose $1 million a year in electrical losses by accepting the low bid versus a 'loss evaluated' cost review of the transformers." Typical response time for transformer, circuit breaker, and circuit switcher bids is 21 days, with a delivery time of three to five months. Allowing the engineer to include important loss evaluation data into the acceptance of submitted bids is essential for cost savings. The more detailed the specification, the less room for uncertainty, and the better application of the product. If equipment is poorly specified, uncertainty with the vendor could cause them to overestimate the cost or affect the quality of the supplied product.

Since a wind farm will be connecting with a utility, it is best to find a firm that has the unique experience of working with regional utility providers. Redundancy in a wind energy substation provides reliability to the utility and improves production opportunities. This redundancy is used to provide continued service even during a single equipment failure anywhere within the system. The engineer and client will determine the necessity level of redundancy based on the understanding of how the system needs to be operated: single verses double substation locations, single verses two power transformers, and breaker bypass versus a transfer bus arrangement. These are a few examples of redundancy or first contingency planning. It is also good planning on the collector design side to install circuits on different sides of the road or along different routes. This is an attempt to avoid any single event preventing the operation of the entire system. Each is designed to interrupt only the affected portion(s) of the system while maintaining output and reliability from the balance of the wind power facility.

Another cost savings area is in decisions that are made based on a limited amount of data. Oftentimes time-warranted judgments concerning communications and monitoring SCADA equipment are deferred until the end of the project. When these decisions are finally made, changes may be required in the drawings or the equipment. Due to rework, modification, or rebuilding of some components of the substation, a hastily prepared plan will expand the cost of the substation design, easily reaching double the engineering cost of a typically designed substation. The later in the process these changes are made, the more costly they may become.

Prior planning for the future is also important in substation design. Recently, a wind farm wanted to add a second phase to the project. Before the original project was constructed a second phase was considered, but it was never mentioned to the engineer. The 150MW substation was constructed at $3.1 million. When the 100MW second phase was brought to our attention, the developer wanted the new substation to be a part of the previously built one. This new substation cost $2.9 million due to the numerous electrical changes that had to take place in combining the two substations. Had the second phase possibility been mentioned earlier, the original substation would have been designed and pre-built with locations in place for future transformers for the expanding wind farm. If the original substation had incorporated the future expansion and constructed with all relevant equipment in place except the future transformers, the

complete substation would have cost $4 million—a savings of $2 million simply from prior planning.

TRANSMISSION

An often overlooked stage in the wind farm process is the transmission line engineering and development. Contacting an electrical engineering design firm early in the development process can eliminate a significant number of unknowns. For bid purposes, preliminary engineering can save a wind developer a substantial sum in anticipated costs by improving initial estimates, determining potential route alternatives, structure types, heights and quantities, conductor sizes, span lengths, and right-of-way widths. Without preliminary engineering, contractors are forced to include many contingencies in their bid that might otherwise be avoided. These contingencies add substantial costs to engineering, procurement, and construction (EPC) bid prices. Pre-engineering can reduce these contingency costs on EPC bids. "Preliminary engineering is critical for optimal construction costs in the bidding process," says Donny Payne, partner of SGS and head of the transmission department.

If the pre-engineering is not performed, it may be determined late in the process that a larger overhead conductor size is needed. A larger conductor may mean stronger poles, which can cost the contractor in both time and money if the project is delayed.

CONCLUSION

In conclusion, while the multidisciplinary Ph.D. program taught me a plethora of information about wind energy, it was not until I began working that I learned how early engineering involvement in wind energy projects is so important. Substantial savings can be found in electrical collection costs from properly sized conductors and in a reduction of cumulative losses. Another significant amount can be saved in substation design due to competitive bidding on proper equipment as specified by the connecting utility. Allowing time for CAD drawings to be done properly will save time and therefore money when there are few to no mistakes and little in way of changes. Early preliminary engineering from a transmission standpoint allows for proper construction bidding by eliminating costly contingencies in the bid process. By reducing costs at each stage of the development, combined total savings can reach several million dollars for a large wind farm when working with qualified electrical engineering companies that have experience working with wind energy.

Wind developers need to be in contact with an engineering company that has a unique perspective on energy production from beginning to end. Money spent on one improvement can be returned several times the cost over the life of the wind project. The "best answer at the appropriate price" means working with consultants for one to two months before the submission of the interconnect request to the appropriate authority.

ADINDEX

Troy Hewitt
global wind energy business leader/Intertek

"As the North American wind industry matures, it is reaching a stage where requirements are more stringent and there have to be guidelines."

HOW AND WHEN DID INTERTEK GET INVOLVED IN THE WIND ENERGY INDUSTRY?

We have a long history of involvement with the energy industry, and when many of the traditional providers began focusing on wind we immediately saw that we could play a valuable role in that market as well. Our point of entry involved the fact that many of the wind farm developers were independent power producers rather than utilities, so they needed a company like Intertek to provide third-party independent power producers that their electrical systems were in compliance. So we began offering that service in 2003, and we've since expanded our capabilities to include turbine testing, inspection, and type certification as well as gearbox oil condition monitoring and lubricant quality testing, among many other services. As an OSHA-accredited National Recognized Testing Laboratory (NRTL) we also conduct small wind testing and certification to ensure compliance with AWEA's new 9.1 standard. We began our work in the wind energy industry here in North America, and we've since established offices devoted to wind services in Europe and Asia. Our primary focus is still on North America, however, due to the activity and volume.

TELL US ABOUT THE SMARTTRACK PROGRAM.

I'd be glad to. Our SmartTrack Program for large wind turbines involves completing field labeling as quickly as possible, and in such a way that we're working through the certification process simultaneously. The program begins with a desktop design review and then moves into a construction review, the development of a compliance plan, completing field label/site inspection reports, and then conducting onsite inspections prior to issuing the certification report. And once those reports are available they're posted on our secure server so that clients can access that documentation at any time. Our stance is that companies should consider capitalizing on all the work they've already done to achieve certification rather than continuing along the field-labeling path. This can be especially useful for companies that are already established overseas that wish to enter the North American market. Another aspect of this process involves prequalification, either of components or entire systems, so that compliance evaluations are performed before shipments leave the factory. That helps avoid unexpected problems in the field and even commissioning delays, which can be quite expensive.

AS A GLOBAL ENTITY WITH A HISTORY GOING BACK 126 YEARS, IT SEEMS LIKE YOU'D BE AN INVALUABLE RESOURCE TO AWEA IN ITS STANDARDS DEVELOPMENT AND TO NREL'S R&D EFFORTS.

Actually, we're pretty heavily involved with both. As a member of AWEA we're helping develop national standards so that OEMs, developers, and owner/operators will know what to expect no matter where they're working. We want to help them avoid situations in the field where an inspector points out something that wasn't required two states away. Some of the areas that we've been involved in so far include the IEC 61400 suite of standards and the new VL6141 for large wind turbine electrical systems and components, as well as others addressing small wind turbines and power conversion equipment. We're also contributing to Canadian electrical systems standards being developed. As for the National Renewable Energy Laboratory (NREL), we're involved in a number of initiatives, one of them being the AWEA 9.1 small wind standard that I've mentioned. We a regional test center for small wind certification, in fact. As the North American wind industry matures, it is reaching a stage where requirements are more stringent and there have to be guidelines in terms of quality assurance and standardization. And while we may never reach the point of true regulatory harmonization between different states and countries, the closer we can get the better off the global wind market will be. We will continue playing an active role in helping build an efficient structure for OEMs around the world to operate within and to help ease their entry into new markets. We can provide a roadmap for companies entering the wind market so they don't have to start from scratch.

For more information go online to www.intertek.com/wind.

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