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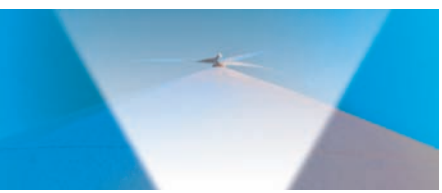

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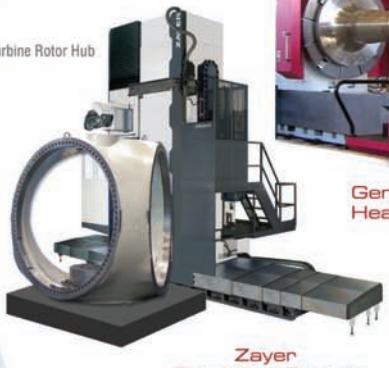

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VOLUME 2 NO. 6

RESOURCES

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EDLETTER

Knowledge is power, to paraphrase English philosopher Sir Francis Bacon, and that's especially true in the wind-energy industry, where poor siting decisions can lead to multimillion-dollar losses. That's why it's good to know that companies like 3TIER exist, providing weather analysis and forecasting utilizing powerful computer models. You'll learn about 3TIER's abilities in this month's Q&A, which features the company's founder and CEO, Kenneth Westrick. I'm pleased to have the opportunity to share some of the high points of our wide-ranging conversation with you.

As for our editorial lineup, we've compiled an amazing collection for you, including "A Greener Wind Farm" by Rachael Elliott and Michael Abrahamsen of the Eaton Corporation. Susan Giordano of Second Wind, Inc., has written "Eliminating Uncertainty with Sodar," discussing how remote sensing is currently coming of age. Christer Richt of Sandvik Coromant points to "A New Direction for Turbine Gearing," sharing news of the company's tooling developments for manufacturing wind-power components, and Josh Underwood of Atmospheric Systems Corp. has penned "Gathering Blade Span Data." In addition, Dale Thompson of the Parker Hannifin Corp. outlines the company's new cooling technologies in "Cool System, Hot Result," and research analyst Paul Kaiser of Marquette University shares his expertise in "Solving the Transmission Dilemma," marking important developments that have been made in recent years. Finally, Jessica A. Graf and Justin B. Mead of Greenberg Traurig LLP discuss the opportunities that exist thanks to The American Recovery and Reinvestment Act of 2009 in "Free Money for Wind Developers."

Our columnists in this issue include new contributor Jose R. Zayas of Sandia National Laboratories, who writes about technology, and Armin Schlereth of SKF, describing the company's new test rig used in the development of high-quality, low-maintenance bearings for wind turbines. James D. Hussin of Hayward Baker geotechnical construction discusses anchoring techniques in this month's installment, and Hüseyin Kizilagac of BDP Project Logistics and Hendrik Wagner, BDP Project Engineering, write about ways to eliminate risk from your wind project before the transportation phase begins. Parkline, Inc.—which originated the self-framing building for protecting electrical hardware—is our company profile, and national sales manager Ron Dawson was very kind in sharing their history and capabilities with me.

As I look over this issue's contents, thinking of working with each of these knowledgeable individuals in developing these fascinating features, I am filled with gratitude for their contribution to this issue of *Wind Systems* magazine and to the wind industry at large. I encourage you to contact me at the e-mail address listed below to discuss how you can make a similar contribution in our pages. All best!

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ROLLER BED FROM ESAB

ESAB Welding & Cutting Products introduces the FUB 30 roller bed for fit-up of sections. This roller bed features a robust design to withstand the rugged environment in the welding industry. Designed to assemble 1+1 sections, the system is fast and easy to assemble. Each set consists of one power and one idler roller bed with four independently adjusted rollers to align the two sections with each other. The roller bed and the rollers are mounted on one main frame. The FUB 30 is ideal for use in fabricating large vessels, wind towers, and pipemills. The FUB 30 offers a maximum load of 30 tons with roller speeds of 130-1295 mm/min. Other features include steel rollers with polyurethane tires, an inverter-style drive control, and a remote pendant with push buttons.

With more than 100 years of experience, ESAB Welding & Cutting Products is one of the world's largest and most knowledgeable manufacturers of welding and cutting equipment and welding filler metals. Recognized as the technological leader in the industry, ESAB is committed to providing customized solutions for its customers. For more information call (800) ESAB-123 or go to www.esabna.com.

JOHN DEERE RENEWABLES ANNOUNCES WIND FARM GROUNDBREAKING

John Deere Renewables, a national leader in wind energy development, has announced the groundbreaking of a new wind farm development project in Idaho. Located in Twin Falls County, the Tuana Springs Wind Farm will consist of eight 2.1MW turbines and have the capacity to produce enough electricity to power more than 5,000 Idaho homes. Christi Ritchie, from Hagerman, Idaho, is the developer on the project. Idaho Power Company is purchasing energy from the project under a long-term power purchase agreement. Groundbreaking began in fall 2009, and

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.

commercial operation of the wind farm may occur as early as spring 2010.

John Deere Renewables funded the Tuana Springs Wind Farm and will also serve as owner and operator of the project, which is the company's fifth mid-sized wind farm development in Idaho. Other projects include the Cassia Wind Farm, Cassia Gulch Wind Farm, Bennett Creek Wind Farm, and Hot Springs Wind Farm. "John Deere Renewables is committed to sustainable rural development and concentrating its efforts on developing mid-sized wind projects like the Tuana Springs Wind Farm," says David Drescher, vice president of John Deere Wind Energy. "Community collaboration is an important part of our development process, as this project may have huge impact on the local economy, from jobs to tourism to tax dollars."

The Tuana Springs project creates new economic opportunities in Idaho. "From our Project 60 economic growth initiative to creating the Office of Energy Resources, making Idaho more energy independent by realizing the potential of alternative and renewable energy production in Idaho has been a cornerstone of my administration's efforts," according to Governor C.L. "Butch" Otter. "The John Deere name brings with it a lot of public recognition and trust. I'm happy to have this exciting new business venture here in Idaho."

"I'm pleased to see John Deere Renewables expanding their footprint in Idaho," says Don Dietrich, director of the Idaho Department of Commerce. "We are pleased that John Deere recognizes Idaho's opportunities in the renewable energy arena. We're happy they're here."

John Deere Renewables offers a variety of flexible ownership structures, including equity participation or ultimate ownership opportunities for the energy customer. The company uses a combination of capabilities and experience to structure projects, which can utilize government programs. For more information please visit www.johndeere.com/windenergy.

NORDEX RECEIVES FIRST U.S. N100/2500 TURBINE ORDER

Nordex USA, Inc., announces an order for eight N100 wind turbines to be installed at a 20-megawatt wind farm in Glenmore, Wisconsin. Developed by Emerging Energies of Wisconsin, the project will generate nearly 64 million kilowatt hours of electricity annually, which is enough to power about 8,000 homes and displace an estimated 55,000 metric tons of CO2 emissions. The CH Energy Group, owner of the New

York utility Central Hudson Gas & Electric Corporation, holds a controlling interest in the project via its unregulated subsidiary Central Hudson Enterprises.

"The project debuts some of the most advanced turbines in the U.S.," says Ralf Sigrist, president and CEO of Nordex, USA. "It's been a pleasure partnering with Emerging Energies to provide the best technology for the site, designed to make the absolute most of Glenmore's wind resources."

The N100s are the latest generation in the Nordex family of 2.5-megawatt N80/N90 turbines. Designed specifically for low to moderate wind speeds, the N100s are ideal for numerous sites across the country, holding great potential in the U.S. The N100s have a hub height and rotor diameter of 100 meters, with a rotor sweep of 7,823 square meters. That translates into an increase in power yield by up to 20 percent at average wind speeds of around 7.5 meters per second, compared to the N90.

For the project, called the Shirley Wind Farm, Nordex will supply cold climate models of the N100s, upgraded to operate in temperatures as low as minus 20° Fahrenheit. "We looked very carefully at the N80/N90/N100 Nordex turbines and were convinced by their great track record, along with the quality and experience Nordex brings to the market," says Bill Rakocy, a founder of Emerging Energies. "We selected the N100s because they accomplish critical project goals, maximizing available land and wind resources by using the largest, tallest turbines available. We're excited to introduce them in the U.S. and in Wisconsin."

The project also represents a shift in the U.S. market toward larger turbines with higher efficiencies and yields. In 2008, the average installed turbine was 1.67 megawatts. Nordex built the first 2.5-megawatt turbine in 2000 and has the longest track record for reliability in the multi-megawatt class, with over 1,000 installed worldwide. Nordex will deliver and install the turbines in the third quarter of 2010, with project completion slated for the fourth quarter. The order also includes maintenance and technical operation under a 10-year service contract. The project carries a 20-year power purchase agreement contract with Wisconsin Public Service Corporation.

"We believe the Shirley wind investment will provide the stability and predictability in earnings and cash flow that our shareholders value," says Steven Lant, chairman of the board, president, and CEO of CH Energy Group. "It strengthens our portfolio of unregulated ventures, complimenting our utility Central Hudson Gas & Electric Corporation."

Nordex USA is currently building a manufacturing plant in Jonesboro, Arkansas, which will produce N90/N100 turbines for the U.S. market beginning in September 2010. For more information go to www.nordex-online.com.

LOW-PROFILE SOCKET/RATCHET SETS FROM SNAP-ON

There's nothing more frustrating than facing a tough fastener job in close quarters and not having the right tool. It's a real world, everyday problem. Low-profile socket/ratchet sets from Snap-on Industrial—a leader in tooling solutions for mechanical, hydraulic, and industrial applications—answer the need for sockets and ratchets that fit cramped quarters. Sizes include 1/4" drive metric and fractional and 3/8" drive metric and fractional, all up to 33 percent shorter than competitive options. Applications run the gamut, from wind-power turbines in the renewable energy market to aircraft and aerospace segments.

The 1/4" drive metric set features a low-profile ratchet and 10 six-point, low-profile sockets. A mini-ratchet with a 72-tooth gear means maximum torque with minimal movement in tight spaces. A thin handle design and easy-action reverse lever allows greater access in small areas. Socket sizes range from 5mm to 13mm. Also, a 10-piece, 12-point, low-profile socket/ratchet set is available in fractional sizes ranging from 3/16" to 9/16". This set is applicable in a variety of markets, particularly aerospace.

The 3/8" drive sets feature an 80-tooth, low-profile ratchet and either nine six-point or nine 12-point low-profile sockets; metric socket sizes range from 8mm to 18mm, with fractional sizes ranging from 1/4" to 3/4". The 3/8" square drive also works with standard sockets. Thanks to Dual 80™ technology and a tighter torque ratio, the 3/8" ratchets require only a 4 ½-degree arc to engage the next gear tooth. The dual pawl ratchet mechanism engages seven teeth to provide strength and durability.

All Snap-on Industrial low-profile sockets and ratchets are manufactured from a special alloy steel that's forged to exacting tolerances and heat treated for optimum strength and durability. Nickel-chrome plating protects against corrosion and makes each piece easy to wipe clean.

The low-profile socket/ratchet offering from Snap-on Industrial recently won a Top 20 Tools award from *Motor Magazine*. Snap-on won a U.S. Technicians' Choice Award for best overall hand tools from Frost and Sullivan in 2008. For more information call (877) 740-1900 or visit www.snapon.com/industrial.

PORT CORPUS CHRISTI MULTIPURPOSE FACILITY PROJECT

Taking the next step in the development of the La Quinta Trade Gateway project, the port commission has approved a Professional Services Agreement for engineering designs with Goldston Engineering, a CH2M HILL company. The multipurpose facility will be designed to handle a wide variety of general cargo including containers, military, wind turbines, steel pipe, and more. Completion of preliminary engineering for full buildout and final design for the initial 800' to 1000' dock will provide the necessary information to define costs and determine completion schedules. The goal is to complete the design and be ready to solicit bids for construction of the first dock by the end of 2010. "This is one more step towards realizing one of the most important port diversification projects," according to John LaRue, executive director. "Goldston Engineering is no stranger to the port. They have worked on many projects with us over the years, and we look forward to working with them again."

GE/CH2M HILL will design the waterside portion of the La Quinta project, which includes the dock and the slip in the channel. The agreement provides for preliminary engineering for the projected full buildout of the docking facilities (three berths) and the final design of the first dock (one berth) and slip. For 59 years, Goldston Engineering was a Corpus Christi based multi-disciplined engineering firm specializing in ports engineering providing planning, design, construction documents, cost estimating, environmental compliance, and construction management services for marine terminals, municipal utilities, transportation, and coastal projects, regionally and abroad. The company has successfully completed many projects for the Port Corpus Christi and has been involved in various studies for the La Quinta project. The company was acquired by CH2M HILL in 2008. The primary economic engine of the Coastal Bend, Port Corpus Christi is one of the 10 largest ports in the United States in total tonnage. Learn more at www.pocca.com.

NREL, SECOND WIND PARTNER ON SODAR RESEARCH

As part of continuing scientific research on understanding wind resources, the U.S. Department of Energy's National Renewable Energy Laboratory (NREL) and Second Wind, Inc., have announced a partnership to characterize the performance of Second Wind's Triton™ sonic wind profiler. Under a Cooperative Research and Development Agreement (CRADA), NREL and Second Wind will conduct research correlating the Triton measurements with measurements gathered from a meteorological tower and will later include Triton measurements in the development of a new Wind Instrument Characterization System (WICS) at the National Wind Technology Center (NWTC) near Boulder, Colorado.

Second Wind develops resource assessment technology for the global wind industry (see related article in this issue). Triton is an advanced, portable sodar (sonic detection and ranging) system that bounces sound waves off the atmosphere and analyzes characteristics of the return signal to calculate wind speed and direction up to 200 meters high. Replacing a 60- or 80-meter meteorological tower and providing much more data, the Triton is changing the way the wind industry does site assessments.

NREL and Second Wind will analyze data gathered from a Triton sonic wind profiler and a nearby meteorological tower during a six-month correlation study completed in 2008-2009. The analysis, expected to be completed in the near term, will characterize the measurement performance of Triton. Next, a Triton will be deployed at the NWTC to collect long-term measurements and compare them to wind resource data being collected from NWTC tall towers.

As part of the CRADA, measurements from the Triton will also be included in the development of a new Wind Instrument Characterization System (WICS) at NWTC. This research will lead to improvements in wind resource assessment and more accurate project energy estimates. "This CRADA will give NREL additional experience with the latest tools being used by the industry for wind measurement," says Dennis Elliott, principal scientist in wind resource assessment at NREL. "This research is vital as the industry moves towards requiring hub height and higher data to reduce uncertainty in the wind resource and turbine performance."

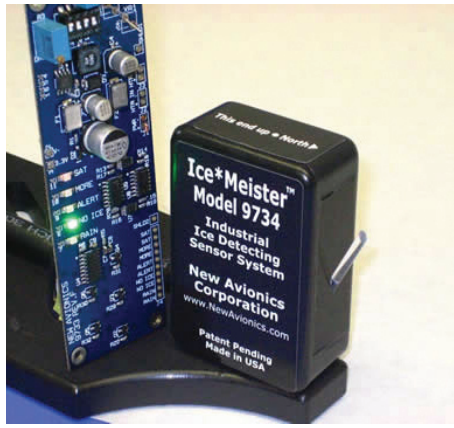
"We are excited to be collaborating with NREL on this project, as it is a great opportunity to work with internationally respected wind experts," says Walter Sass, CEO of Second Wind. "We are looking forward to working with NREL on an in-depth review of the Triton technology performance, and to making a contribution to NREL's scientific research on wind instrument characterization."

For more information go to www.secondwind.com and www.nrel.gov.

ICE SENSOR FROM NEW AVIONICS

The new Ice*Meister™ model 9734 industrial ice detecting sensor system offers many benefits to wind turbine owners and operators. Once "tuned" for the application at hand, the device operates as a digital ice/no-ice indicator. At maximum sensitivity it detects the incipient formation of any kind of ice, even the condensation from human breath, and also determines ice thickness. It detects and "stretches" raindrops for efficient control of irrigation sprinklers, and it detects the point at which rain has turned to ice. It is ideal for use in hazardous, remote, and/or unattended locations, also offering an optional de-ice heater for system reset.

The model 9734 precipitation sensor system runs on about a watt from virtually any available power source of any polarity—primary batteries, solar panels, six-volt motorcycle batteries, and even cell phone chargers, AC and DC alike. The three components of the



Ice*Meister are the sensor head, the cable, and the interface board. Users provide raw input power and receive data output via indicator LEDs and isolating relay contacts, which helps to avoid system ground loops. The user interface board tunes the sensor head to specific applications, and various options are available for the sensor head and cable assembly. To learn more contact Richard Hackmeister at (954) 568-1991, rlh@newavionics.com, or www.newavionics.

GE RECEIVES CONTRACT TO SUPPLY TURBINES FOR LARGEST U.S. WIND FARM

GE has received a $1.4 billion contract from independent power producer Caithness Energy to supply wind turbines and provide services for an 845MW wind farm project to be located in Oregon. The wind farm, called Shepherds Flat, has received the majority of the necessary government permits to operate and is ready to be built. When completed it will be larger than any wind farm currently in operation around the globe.

"This project underscores our commitment to harness the power of wind to meet present and future energy needs while reducing greenhouse emissions," says Les Gelber, a partner at Caithness Energy. "The Shepherds Flat project will add more renewable energy to the west coast's energy mix and help the region meet its demand for clean energy."

Stretching across 30 square miles of Gilliam and Morrow Counties in north-central Oregon, near the town of Arlington, the Shepherds Flat project marks the U.S. debut and largest single global order of GE's 2.5xl wind turbines. A total of 338 turbines will be installed in 2011 and 2012. "GE wind turbines have a strong track record of performance that has been proven in nearly every form of climate worldwide," Gelber adds. "Their ability to continually advance wind turbine technology will help

us to provide our customer, Southern California Edison, with the reliability they expect."

"The Caithness project highlights our ability to deliver integrated solutions in the clean energy space, and it supports our overarching focus to provide first in class technology to our customers," says Steve Bolze, president and CEO of GE Power & Water.

GE's 2.5xl wind turbine has been proven in Europe and Asia. "The 2.5-MW wind turbine is the latest evolution of GE's wind turbine technology and provides customers with greater efficiency, reliability, and grid connection capabilities," Bolze explains. "The 2.5-MW builds upon the success of GE's 1.5-MW wind turbine, the world's most widely deployed wind turbine with more than 12,000 installed."

In addition to supplying the wind turbines, GE will provide 10 years of operational and maintenance services to the project. The 2.5xl wind turbines for the Shepherds Flat wind farm will be assembled at GE's site in Pensacola, Florida. Under three 20-year power purchase agreements, the Shepherds Flat wind farm will supply renewable energy to Southern California Edison, an Edison International company. The project will provide enough clean energy to power approximately 235,000 average California households, according to U.S. Environmental Protection Agency methodology, and will avoid more than 1.5 million tons a year in greenhouse gas emissions compared to equivalent fossil fuel generation. For more information contact Howard Masto at (518) 385 2381 or howard.masto@ge.com. Go online to www.ge.com.

EASY SHAFT ALIGNMENT FROM LUDECA

SHAFTALIGN is a high-precision, easy to use shaft alignment tool incorporating human error-proof functions. With its TFT backlit color display it combines simplicity of operation with precise measurement and state of the art technology. Intuitive auto-flow capability guides the user to obtain the desired machinery alignment condition. The innovative "active clock" measurement mode automatically collects the laser coordinates for the corresponding shaft position. Only three readings over a rotation angle of less than 70° are required to achieve a precision alignment. All relevant alignment results are displayed in one screen, including the alignment status evaluation. A built-in light sensor optimizes screen image quality and power management. Rechargeable batteries save operating cost and contribute toward a greener environment.

SHAFTALIGN is upgradable to more-powerful features as alignment requirements increase. The tool offers a variety of options to generate and archive alignment measurement reports through its freeware, Alignment Reporter PC software, or through the direct reports as PDF to a memory stick. Precision alignment contributes to savings in the consumption of electricity and extends the life of bearings, seals, and couplings. For more information go online to www.ludeca.com.

3TIER ON DOE TEAM FOR SMART GRID DEMO

The Department of Energy (DOE) has selected a Pacific Northwest team including 3TIER—a global leader in renewable energy information services—to conduct a regional smart grid demonstration project. The project will test new smart grid technologies including devices, software, and advanced analytical and forecasting tools that enhance the power grid's reliability and performance. The Northwest study will involve more than 60,000 metered customers in Idaho, Montana, Oregon, Washington, and Wyoming.

"The inclusion of 3TIER in this project acknowledges that optimizing the energy supply side of the smart grid equation, and renewable energy in particular, is absolutely critical to the long-term success of an efficient and smart national grid," says Kenneth Westrick, founder and CEO.

3TIER will provide wind and solar power forecasting for individual sites and for the region as a whole for the duration of the project. The company's hour-, day-, and week-ahead forecasts will be processed centrally as part of an integrated smart grid system. 3TIER is one of the largest forecasters of wind energy in the world, forecasting production for more than 16.5 GW of regional and 11.6 GW of project-specific installed capacity, including more than 30 percent of the installed capacity in North America.

"A key objective of a national smart grid infrastructure is to make the best possible use of renewable energy resources," Westrick says. "Accurately forecasting weather-driven renewable energy provides the signals the system needs to optimally integrate that energy into the grid, and dispatch other assets when production decreases. It is an essential component of an efficient and reliable smart grid system."

The Pacific Northwest Smart Grid Demonstration Project team combines energy providers, utilities, technology companies, and other research organizations. Total estimated cost for the project is $178 million. The DOE will provide half the funding through the American Recovery and Reinvestment Act. The project's participants, primarily utilities, and industry team members—including 3TIER—will provide the remaining funds.

At its peak the project could create about 1,500 total jobs in manufacturing, installation, and operating smart grid equipment, telecommunications networks, software, and controls in the five states. The DOE press release is available at www.energy.gov/news2009/8305.htm.

Founded in 1999, Seattle-based 3TIER is one of the largest independent providers of wind, solar, and hydro energy assessment and power forecasting worldwide. For more information see the Q&A in this issue, and visit www.3tier.com.

TURBINE GENERATORS FROM WINDGEN AMERICA

In spite of an expanding wind power industry, the North American market has steadily relied on imported wind generators. That is about to change. WindGen America, LLC, is in the process of building the first wind turbine generator manufacturing facility in the Untied States. The company's principals have extensive wind power experience and will be using it to develop and manufacture wind turbine generators for the North American market.

The generators under development

at WindGen America will be 660 KW and 2.5 MW permanent magnet design. With prototypes up and running, these designs address the weaknesses in conventional wind generators. The past and current wind generators have been fraught with high maintenance costs. Designed and built for wind power applications, these generators will offer the industry a choice. Not just American-built, but built to exceed the demands placed on conventional wind turbine generators.

A convergence of wind power growth and incentives to provide U.S. manufacturing jobs have created the right climate for this enterprise. In addition to developing superior generator designs, WindGen America has focused its attention on a facility whose efficiency will match its turbines. Locating in an eastern industrial hub, WindGen America will be able to take advantage of existing road, rail, and ocean port facilities. Starting from scratch, all aspects of the operation will utilize the latest technology maintaining high quality while keeping manufacturing costs in line. Simplifying logistics, the company will be able to supply the nation with the latest in turbine generator design at a very competitive price. The 100,000 sq. ft. facility will have a labor force comprised of 120 skilled technicians onsite. The initial production target is 1,500 generators per year. For more information go to www.windgenamerica.com.

SEAROC JOINS NATURAL POWER

SeaRoc—the marine, engineering, and offshore experts—are joining Natural Power to form the first renewable energy consultancy truly capable of providing end-to-end services globally for the industry both onshore and offshore. The announcement follows almost 18 months successful operation under a framework agreement and an existing minority stake acquired earlier this year. Natural Power has already consented over 1,300 MW of client projects offshore. SeaRoc, which sits on two BWEA steering committee groups, provide marine, engineering, health and safety, and environmental services to some of the UK's biggest renewable energy projects. Sister company SeaPlanner provides world class GIS expertise and extensive data management knowledge to the offshore market.

Natural Power and SeaRoc will form a group of over 220 highly skilled resource engineers, development specialists, construction engineers, marine managers, GIS experts, and asset managers based across 11 offices worldwide. The Natural Power group will be a world-class wind, wave, and tidal service provider in the areas of due diligence, engineering, development, construction, operations, and health and safety both onshore and offshore. The group creates a single source for complete lifecycle services for the industry.

Stuart Hall, director and founder of Natural Power, says that "Having provided lifecycle services onshore for the past 15 years, and consented over a gigawatt of client projects offshore, it is a natural step forward to complete the loop by welcoming SeaRoc to the family. They are the experts offshore. The announcement reflects the needs of our clients for a single provider of both onshore and offshore services, which we are delighted to now offer."

Peter Hodgetts, CEO and founder of SeaRoc, adds that "We are looking forward to joining the Natural Power family. There

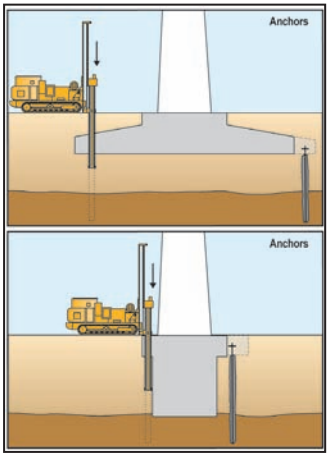
Continued on page 58 >

James D. Hussin
Hayward Baker, Inc.

Both wind and weight create tremendous forces on tower foundations, making anchoring techniques particularly critical. Here are points to keep in mind.

WIND TOWERS ARE NOT PARTICULARLY heavy, but are subject to high lateral loads at a distance high above their base, resulting in a large overturning moment. This loading condition results in a downward load on the downwind edge of the foundation, and an upward load on the windward edge. Seismic loading, where applicable, further increases these overturning loads.

For shallow mat foundations, the downward load bears on natural or improved soils. The uplift load can be resisted by the weight of the foundation and additional surcharge placed above the footing. Increasing the mat diameter can also increase the resistance to the overturning moment. Deep foundation systems resist the moment couple by compression, tension, or bending of the deep foundation elements. When individual piles are utilized, the downwind elements resist the moment load in compression and the windward piles in tension. Tower foundations supported by a drilled shaft or a concrete cylinder are designed to withstand the moment in bending.



The uplift capacity of tower foundations can be increased by incorporating soil or rock anchors into the foundation system. Soil and rock anchors are tension elements which develop their capacity by bonding into soil and rock, respectively. Anchors are typically constructed by first drilling a 6- to 12-inch diameter hole into a stable soil or rock formation. A high-strength steel bar or strand (cable) is then placed into the hole, and the hole is filled with a high-strength cementitious grout. The top of the bar or strand is then attached to the foundation. When the foundation is subjected to an uplift load, the anchor resists the load by going into tension and transferring the load to the stable soil or rock formation. Soon after construction of an anchor, the soil-to-anchor or rock-to-anchor bond can be enhanced by pressure grouting the bond zone.

The design of the steel bar or strand is based on standard steel design with the appropriate factor of safety. Thread bars are available in 150 ksi steel with diameters up to 3 inches, providing an ultimate strength of 500 tons. Strands are available in 270 ksi steel. A single 0.6 inch diameter strand has an ultimate strength of about 30 tons. An anchor can be constructed with multiple strands, achieving over 1,500 tons. Typically the ultimate capacity of an anchor is limited by the strength of the soil or rock into which it is bonded. Anchors are available as a design/build service by specialty contractors.

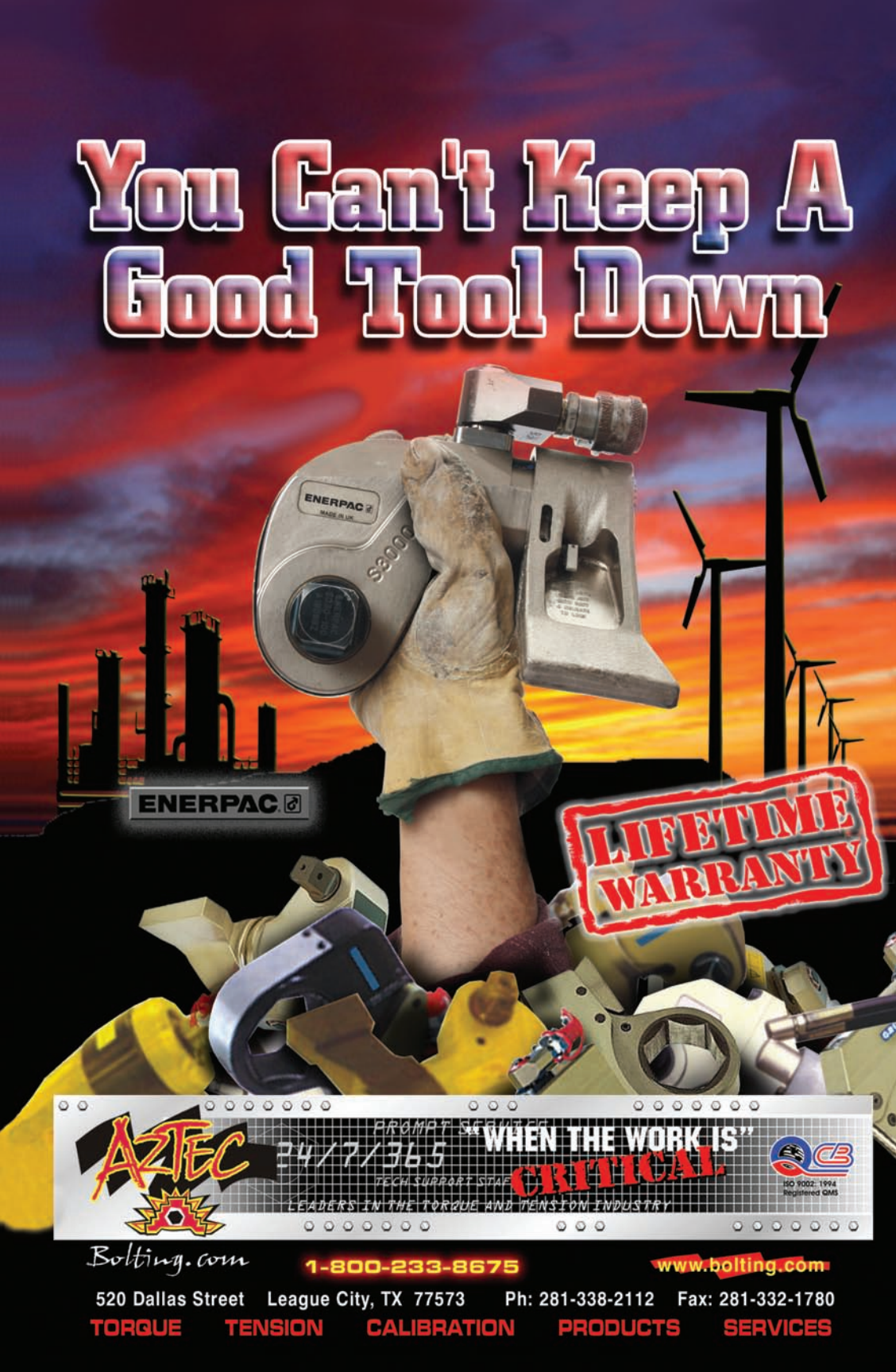
By incorporating anchors into the initial foundation design, the foundation diameter, thickness and/or embedment depth can be reduced, potentially saving on the cost of the foundation. The anchors are located near the perimeter of the mat to maximize the overturning resistance per anchor. The foundation may require additional reinforcing steel to transfer the forces from the tower to the anchors.

Anchors can also be added to existing foundations (deep or shallow) that require additional uplift capacity. Again, locating the anchors at the perimeter of the foundation maximizes the moment resistance per anchor. The anchors can be installed through the existing foundation, and then the anchor head is bonded to the foundation. Alternately, the anchor can be installed adjacent to the foundation and then connected by dowels or an extension of the existing foundation.

Since anchors are a permanent part of the foundation, corrosion protection is an important aspect of the design. Corrosion protection is achieved through a variety of applications, including greasing and covering the steel, applying epoxy to the steel, or using galvanized steel. The grout surrounding the anchor steel provides protection from oxygen, and it is often supplemented with corrugated plastic pipe. The bars and strands can be ordered from the supplier already grouted into corrugated pipes. The corrugation provides the mechanical bond when the elements are grouted into the soil or rock.

Quality control measures include monitoring grout quality, quantity and pressure during grouting, and conducting load testing of installed anchors. Unlike traditional pile foundations where a limited number of piles are load tested, every anchor is load tested. Properly designed soil and rock anchors can provide an efficient and cost-effective component of a new tower foundation system or a remedial solution for existing tower foundations requiring additional uplift resistance.

James D. Hussin is a director with Hayward Baker, Inc., the leading specialty foundation and ground improvement contractor. He can be reached at jdhussin@haywardbaker.com. Go online to www.haywardbaker.com.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TORQUE TENSION CALIBRATION PRODUCTS SERVICES

Armin Schlereth
SKF

As the market in wind turbines grows so does the demand for large, low-maintenance bearings. SKF has built a unique test rig for large bearings used in wind turbines.

ALTERNATIVE ENERGY GENERATION is becoming an important part of the power generation mix, and it is likely that the size of individual generating units will grow. With 3 MW turbines standing at a height of 295 feet, large bearing systems are required at the heart of the generation machine. This is why SKF has built a test rig to support the validation of new bearing designs and advanced calculation tools in a full-scale bearing.

Along with increasingly greater installed power is the trend for increasingly larger bearings inside the turbines. The most commonly produced SKF main rotor shaft bearing is a special double row tapered roller bearing with an outside diameter of almost 2.4 meters (7.9 feet). This bearing is the largest main rotor bearing for wind turbines manufactured in series production. So far some 1,500 bearings have been produced for one customer.

These turbines are frequently sited in remote geographic locations, which are often difficult to access. This creates an increased demand for reliable performance of both the turbines and the bearings in the equipment. Despite its long and successful history in bearing development, SKF development engineers are faced with the need to answer a basic question from wind power customers: "Are your calculations validated?"

After an extended evaluation of the testing strategy, the decision was taken to develop a full-scale test rig that enables the engineers to investigate these very large bearings. The SKF test center in Schweinfurt, Germany, was selected to design, build, and operate the test rig. The development of the test rig involved a continuous assessment of the intended and the achievable goals within the set time frame. Indeed, the rig was completed within an 18-month time frame. The design and construction of the test rig involved the definition of the test and measurement parameters; the development of the test rig design; finding appropriate suppliers for the rig components; and advanced calculations of the rig components and of the bearings in the loaded conditions.

Large double row tapered roller bearings can now be tested close to the factory instead of in the final application, without all the implications of accessibility and varying operating conditions. The bearings can be tested at speeds up to 60 rpm, which is more than three times the speed used in real applications. The rig enables various lubricants, lubricant distribution, and lubrication conditions to be monitored closely, while the bearing loads can be increased up to twice the load-carrying capacity of the bearing. At the same time the friction performance, elastic deformations, temperatures, and other parameters are evaluated.

The new test rig enables the validation of SKF's advanced calculation tools for large-size applications in terms of friction performance, lubrication behavior, seal performance, and life calculations. New designs and manufacturing processes can be validated in full scale, and important information on material response can be derived from the tests. SKF's condition monitoring equipment installed on the rig enables the service condition personnel to hone their skills without traveling to remote locations.

Since the start of the testing campaign, the rig has drawn high-level attention to SKF from both customers and political leaders. The test rig proves SKF's leadership in this bearing technology, its contribution to the reduction of energy consumption and the support in generating "green" energy. The test rig will be an important steppingstone in entering the even bigger and more powerful wind turbine market of the future.

Ensuring that designs for new large bearing systems for wind turbines meet their designers' expectations in operation is the job of SKF's new testing facility in Germany. Built in just 18 months, the test rig allows large bearings to be put through their paces before they start operation in some of the toughest locations and weather conditions in the world. As turbines grow in power and size, SKF sees the new test facility as a major support in the development of new bearing solutions for the wind power market.

Armin Schlereth is manager of testing in the SKF Automotive Division. Thanks to *Evolutions*, www.skf.com.


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Jose R. Zayas
Sandia National Laboratories

Sandia National Laboratories initiates a program to address the challenges of manufacturing dependable, cost-effective blades for wind turbines.

A ROBUST, RELIABLE, AND HIGH-QUALITY supply chain of wind turbine blades is crucial for the sustainability of the wind industry to ensure growth and projected demands. With approximately 8,300 MW installed in 2008, and 5,800 MW installed through the third quarter of 2009, the demand for wind energy in the United States has experienced exponential growth over recent years and has led to a large capital investment in U.S.-based manufacturing. Typical utility scaled wind turbine blades being manufactured today can range between 30 to 60+ meters in length, but given that all U.S. installations are land-based the range is between 30 to 45+ meters. Wind turbine blades pose manufacturing and supply chain challenges given their large size, large amount of raw materials, and significant labor content associated to the various accepted manufacturing processes. Additionally, in order to meet demand and support large and emerging global markets, some utility scaled turbine manufacturers have their own blade manufacturing, while others have chosen to purchase them from component suppliers to displace risk and large capital investment in manufacturing infrastructure.

Focusing on a record year, 2008, where approximately 8,300 MW were installed across the U.S. and the average machines being 1.5 MW in size (~40 meter blades), ~16,700 blades were manufactured just to meet the U.S. installations. A typical 40 meter blade weighs approximately 12,500 lbs, is composed of fiberglass—some OEM's have carbon fiber on spar cap, core material (balsa wood or foam), and a resin system (epoxy, polyester, or vinylester)—and is primarily manufactured through an infusion process. Out of the total weight of a blade the dry fiberglass can represent 70 percent of the total weight, the resin 25 percent, and the rest is the coring material. The raw material supply and delivered quality is crucial to manufacturing a high quality product that not only can meet the certified requirements, but also survive the industry average design life of 20 years. Recent publicly announced large failures of blades reminds us of the importance of design, manufacturing, testing, and the supply chain to ensure the sustainability of this industry.

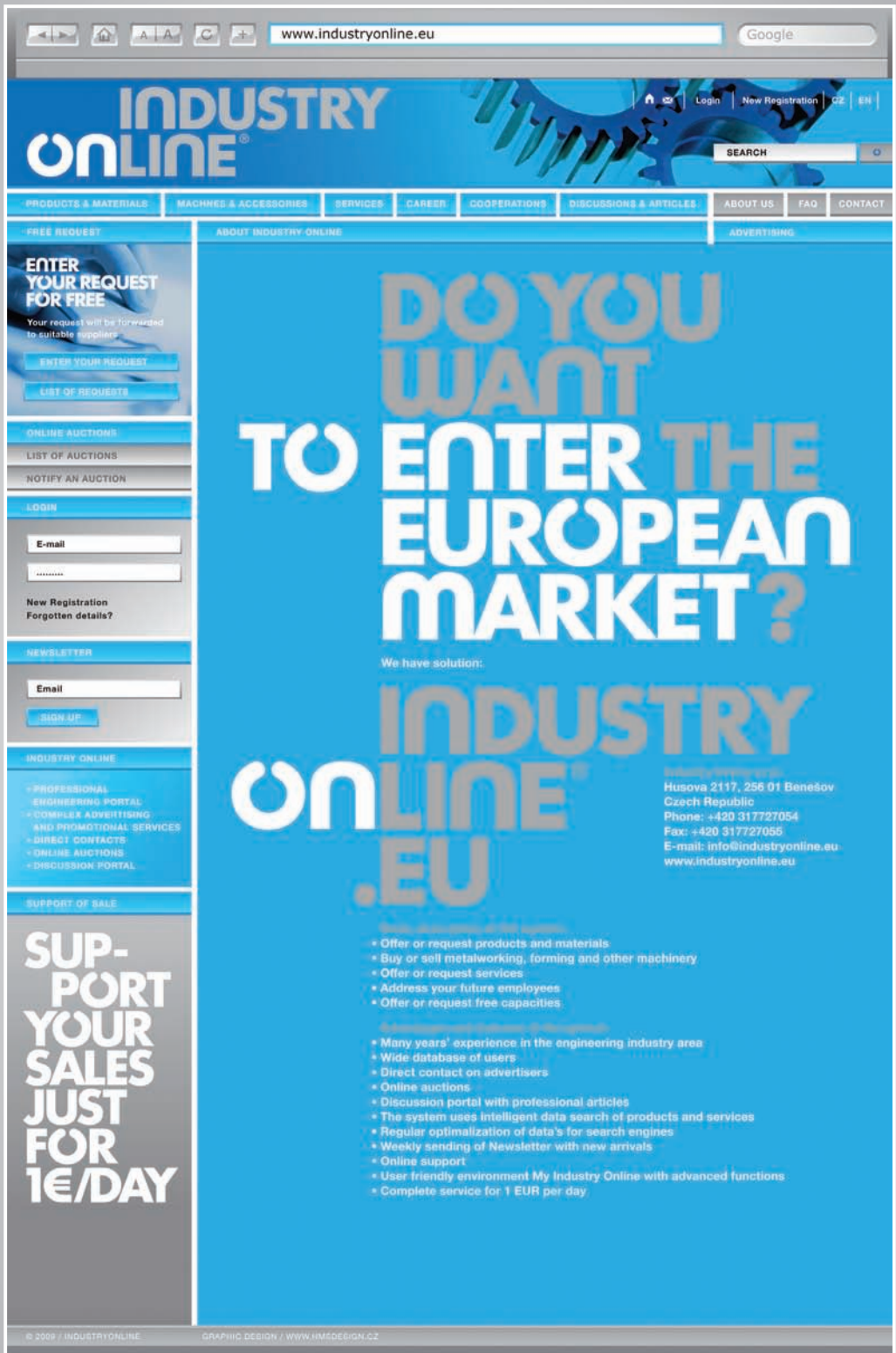
Sandia National Laboratories (SNL), through the support of the Department of Energy (DOE) Wind and Hydropower Technologies Program office, has embarked on a manufacturing program to address the challenges and opportunities of manufacturing high quality cost effective wind blades. The program is mutidisciplinary in nature, where quality, reliability, and cost effectiveness are the primary metrics for success.

To address and ensure quality, the program targets improvement opportunities in robust and lean manufacturing techniques to minimize human errors, given the labor intensiveness in manufacturing, and nondestructive inspection techniques (NDT) to identify and address issues in the finish product prior to shipment and delivery. The nondestructive techniques typically used for wind blades, ultrasonic and thermography, provide mixed results and vary in applicability given the complex geometry and internal architecture. Through experience and design, knowledgeable manufacturers inspect critical regions and developed guidelines for acceptable flaws. SNL's manufacturing program evaluates all available applicable NDT techniques to develop a portfolio of options that will minimize false-positive inspection results, which can lead to field problems where the cost of repair grows exponentially.

Another objective of the program is focused on automation and increased plant throughput. Given the small margins in blade manufacturing, the program focuses on quantifying optimal plant layouts, given manufacturing process and sequence, and identifying the most promising areas to automate given the capital investment and equipment payback time.

Given expert projections or the results of industry studies—such as the DOE 20-percent by 2030 scenario where the analysis documents the viability and improvements needed to achieve 20-percent wind energy by the year 2030—it is clear that a high-quality wind blade supply chain is needed. Although the research results at SNL are ongoing, the program is designed to disseminate these findings throughout the program in support of this growing industry.

Jose R. Zayas is program manager, Wind & Water Power Technologies, at Sandia National Laboratories. Go online to www.sandia.gov/wind.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Hendrik Wagner, BDP Project Engineering
Hüseyin Kizilagac, BDP Project Logistics

Engineering solutions can mitigate increasingly complex infrastructure problems, allowing you to eliminate risk from your wind project before transportation

FOR THOSE RESPONSIBLE for the construction of wind farms, risks literally could be just around the corner. If your project logistics resources do not have extensive civil engineering experience, there could be serious consequences—from missed deadlines to cost over-runs. You want a resource that anticipates every curve in the road. The logistics provider's civil engineering services should not be limited to transport issues. They must be in a position to provide a complete planning and fulfilment package: every step from port of import to the windmill foundation.

Not surprisingly, the devil is always in the details. You need resources that are proactive. Be sure to demand a tailor-made solution—combining project logistics and project engineering. That is why you must look for experience from your project logistics resources in all facets of civil engineering services: bridge inspection, surveying, site supervision, consulting, structural analysis, civil, and road design.

You want bridge and road and construction engineers who are infrastructure experts, not just machine engineers and transport engineers. Specialized engineers who have structural, geotechnical, and road design expertise, and preferably an engineering division that can handle the drafting, planning, approval, and execution of temporary and permanent traffic infrastructure measures for special transportation. This should include an experienced team of road and bridge planners with the corresponding technical equipment on hand. Specific services you should look for include:

- Ground investigations;
- Geotechnical reports, including subsurface assessments;
- Planning of ground improvement for site roads;
- Crane studies, including the geotechnical proofs of supports;
- Planning and geotechnical proofs for temporary construction of road systems;
- Drawings of transport configurations and the review of configuration-dependent turning radii for vehicles and loads;
- Complete and extensive route reviews;
- Surveying services at geometrically critical passages;
- Support in negotiations with authorities;
- Visualization and animation of operations.

Even though the distance between each wind turbine may be small, the location of each can provide different challenges. Surface surveys and geotechnical surveys can help to identify infrastructural and topographical problems. Your project logistics engineering provider should have a highly specialized network of resources around the world, as well as solid, reliable references. Due to advances in equipment, wind power production will become more effective, pushing boundaries and challenging producers and their resources.

Blades are now moving to places where greater amounts of wind are available. In such areas infrastructure is either very weak or almost nonexistent, often with high ascents and descents. In some countries there is no wind power transportation system, and blades and towers require special transportation. When equipment is not available in those locations, it has to be brought in from outside.

At complicated job-site areas geotechnical surveys will be needed, as well as additional infrastructure activities. Look for a combination of transportation competency and infrastructure competency in your project logistics provider. In some cases, wind power companies may not realize they are paying for services and equipment they do not need. Some project companies and suppliers tell their clients they must bring in "x" number of cranes or build additional roads. This unnecessarily increases the infrastructure costs. With the right planning you can adjust and/or level the descent and ascent from one windmill location to another, so that the crane can move without being disassembled.

Look for a provider that wants to provide a solution and has the right equipment in place with the right infrastructure services for the project. Be sure your project logistics provider measures everything that matters. You want a reliable resource that gives you control of your project—one that considers cost, time, and always meets your deadline.

Hüseyin Kizilagac is director of business development, and Hendrik Wagner is director of project engineering, for BDP Project Logistics. E-mail hueseyin.kizilagac@bdpprojects.com or hendrik.wagner@bdpprojects.com. Go online to www.bdpprojects.com.

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PARKLINE, INC.

By Russ Willcutt

With an innovative self-framing building system, years of accumulated expertise, and a reputation for meeting deadlines, this company can protect your electrical assets.

WHEN YOU DELVE INTO THE HISTORY of many companies you'll often discover humble origins, with the founders making their debut in a basement, garage, or spare bedroom. But a doghouse? Such was the case for Parkline, Inc., but perhaps not in the way you'd imagine.

"Our story began in the 1930s, when the Parkersburg Rig and Reel Company came up with a new design for the small structure found on the back of a drilling rig that's known as a doghouse," according to Ron Dawson, Parkline's national sales manager. "What they came up with was a structure that could be assembled, disassembled, and used over and over. This was the original self-framing building, which we are still known for today."

Although Parkersburg passed through several hands over the years, including Butler Manufacturing, in the early seventies a group of longtime employees purchased the rights to the self-framing design and launched Parkline in 1972. The company became 100-percent employee owned and operated in 1996, and since that time it has tripled its sales, doubled its workforce, expanded its facilities—it is currently undergoing additional growth, as a matter of fact—and retired its purchase debt in 2009.

With markets served including electrical, oil and gas, and telecommunications, among many others, Parkline marked its entry into the wind-energy industry in a particularly impressive manner. A few years ago the general contractor for a wind farm that was under construction requested a quotation for the buildings it needed to house electrical hardware. "The guy warned me that they'd already contacted two other companies who told them their deadline couldn't be met, so we knew that it would be a challenge going in," Dawson recalls. "We discussed it among ourselves and then told them there was no reason we couldn't complete our work within their timeframe, as long as they held up their end of the bargain. Not only did we land the order, we had the buildings up and operational before the final deadline had arrived."

What enabled Parkline to meet this customer's needs when others said it wasn't possible? It's a long list, beginning with the fact that employee/owners tend to be more motivated than most. But it also has to do with the company's decades of accumulated expertise, that it subcontracts very little of its work—even manufacturing its own hollow doors and windows—and generally keeps about $5 million in raw materials on hand. Add these things together and you have a partner that's more than capable of expediting important orders.

Still, these self-framing storage buildings are about much more than four walls and a roof, and Parkline is able to provide a great deal more than shelter from the elements. Once the customer has provided its electrical scheme and a list of the various components it will house, the size of the building is determined, in addition to what type of HVAC system will be required. The extent of Parkline's involvement is also discussed, which can be limited to building/erection and extend all the way to installing the relay and control panels and other necessary equipment. "We are prepared to provide a complete turnkey package if that's what the customer would like," Dawson says. "All they need to do is tell us what they want and we'll do the work, hand over the keys, and we're out of there. That's one part of this huge project the contractor won't have to worry about."

Another benefit of having been around for so long is the knowledge Parkline possesses as to different state regulations for the types of structures it manufactures. While they are built at the company's headquarters in West Virginia, the buildings may be headed to a wind farm in Oregon, and the paperwork proving all codes for that state have been met must be provided in order for the project to proceed smoothly. "And now there are even codes in some states that lay out how much energy a building can consume, so you've got to be aware of where these laws are in place and what's required," he says. "We've made a point of being certified in all the states that have those particular codes in place."

Manufacturing in excess of 1,000 buildings each year—including single slope, gable roof, site-built, and pre-assembled models, for example—Parkline can boast having more than 70,000 of its building systems in place around the world. "It's great to have that kind of history and reputation, but we take every project we're involved in as if we're proving ourselves for the first time," Dawson says. "That's how you keep your good reputation alive, and build on it."

Call (800) 786-4855, e-mail rdawson@parkline.com, or go to www.parkline.com.

GATHERING BLADE SPAN DATA

Compiling a complete range of data is the only way to determine whether a potential wind-farm site is viable and will produce as desired.

By Josh Underwood

Josh Underwood is with Atmospheric Systems Corporation. Call (661) 294-9621, e-mail josh@minisodar.com, or go to www.minisodar.com.

I'M NOT A BOUNDARY LAYER METEOROLOGIST, nor do I have a degree in engineering, but I do possess something that makes me unique. I entered the wind energy industry believing that remote sensing was the standard. This perspective opened my eyes to the way things could, or should be. Before continuing I should point out that this article isn't about remote sensing, per se, but the data that remote sensing and tall towers provide. My experience falls within the area of sodar.

Analyzing the Info

When I made the decision to enter the wind energy industry I left a field that analyzed historical data and used it to predict the future, so in many ways my transition seemed like a natural evolution. Wind resource assessment and next-day power predictions really are equivalent to what I'd done before, the data is just applied differently. The algorithms may not be the same, but the overall concept is identical: look at the past, predict the future.

My first task was to correlate met tower data to a remote sensing device. This was a fairly easy task. I simply took two sets of data—one from a 60 meter met tower, and the other from a sodar—and chronologically arranged them in an Excel spreadsheet. Using the handy chart wizard, I plotted several graphs. There were time series and correlations for every level. The time series appeared as though one set of data was lying right

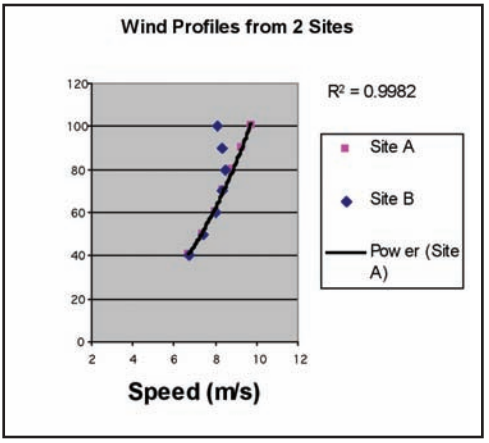

Fig. 1: Data from two different sites for comparison.

on top of the other. The correlation provided a linear fit with a slope of roughly .98 or .99. There was absolutely nothing special to note about this step of the process. Everything I saw was exactly as it should be, and the tower and the sodar matched well. They clearly were measuring the same regime, and the shears from level to level looked just fine. As I said before, up to this point the process was very uneventful.

After confirming that the mutual levels were in agreement, I was asked to look at the data at the hub height. Using every wind resource assessors' favorite formula, $u/u_r = (z/z_r)^{\alpha}$ —aka the power law—I took the met tower data and calculated hub height data for every single data point. Since the sodar collected data at the hub, I had no need to apply the law to that data set.

The extrapolated tower data projected higher wind speeds than that of the sodar. I really wasn't too concerned. I figured that the formula was limited and was mostly designed as a model and not the rule. Since this was my first run, I consulted a meteorologist to confirm my results. Based on the terrain and location, I was told that this made perfect sense.

The site was questionable at best based on the sodar data, but it looked pretty good from the extrapolated data. So the client asked me to rework the data several times over. I really didn't understand why. The data was pretty clear, but they were the client. I had several years of data, so I looked at specific years, then all of them together, and so on. I broke down the numbers by month and direction, and still the results suggested the same things. Eventually they decided to carry on with the project based on the extrapolated data, yet it was clear as day to me that it wasn't a great idea.

Deriving the Data

I'm sure there were many internal factors that informed their decision. Maybe they proceeded just because they could get funding on the tower data alone at the time. I still don't know the answer, but I do know that a financial organization shelled out investors' money to develop a borderline site. Maybe tax credits would push the site into profitability, but there are definitely much better sites to consider for investment. This indifference to the actual hub height data inspired me to write this article. If I were a banker or a developer, I would want to know what is going on at the blades of a turbine since the technology exists that provides this data. I must admit that I can be a bit of a penny pincher, but wouldn't you want to know everything about the wind profile before you write checks for millions, or even billions of dollars?

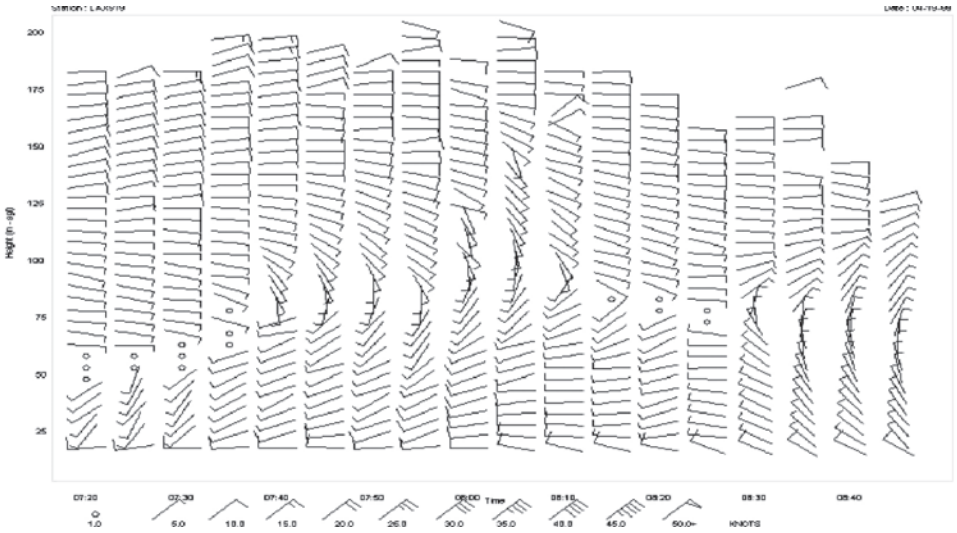

Fig. 2: Barbs representing wind speed and direction.

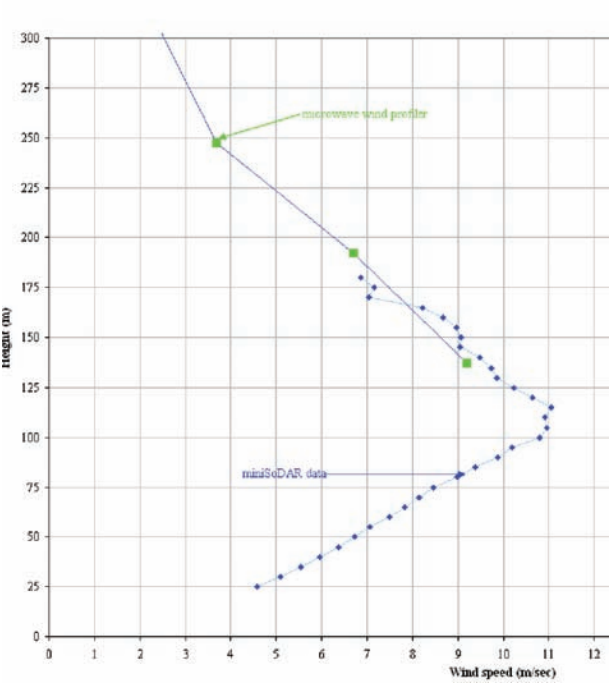

Fig. 3: Readings from a lower-level jet in Texas.

Review, for example, the chart shown in fig. 1. The data is from two different sites. Notice that the two wind profiles are very similar up to the 70m mark, and almost identical to the 60m mark.

Site A is a site that follows the power law. The data has an R-squared value of 0.9982. Everything looks similar to what the extrapolation would suggest. There are many sites out there that fit this mold, and I am completely aware of this point. However, not all of them fit the bill. Site B is in a location without much in terms of complex terrain, but starting at 70m the shear begins to back off and eventually becomes a negative shear. These two sites will not produce the same amount of power. Actually, site B would produce less power since it has wind speeds close to 2 m/s less than that of site A in the blade swept area. Even worse, had the developer chosen to put up 100m hub height turbines, site B would dramatically under-produce based on the extrapolations. That is a fatal flaw with extrapolations. If there is a positive shear at levels with data, an extrapolation will predict that the wind speed increases the higher you go. As you can see from site B, this is not always that case.

Another strong example that I have seen firsthand is an on-shore/offshore flow. The chart in fig. 2 shows wind barbs that represent wind speed and direction. As you can see, the wind changes approximately 180 degrees around the typical hub height of a turbine. By looking at the 60m level and below—and in some cases 80m and below—this event would be missed. Onshore/offshore flows can be seen near coastal regions or near large bodies of water. While this particular image may be on the extreme side, wind-changing direction with height can be seen in numerous locations. In fact, I'm sure there

are plenty of blooper reels with major league baseball players dancing around trying to follow a fly ball as it moves in the wind. Candlestick Park is probably featured in many of them.

Levels Don't Lie

In other instances, this data can optimize wind farm construction. The chart in fig. 3 shows a lower level jet in Texas. The terrain is very flat, with no complexities. Based on the information seen to the left, one can maximize the production at the site. As hub heights reach upward of 160m, this information can prove to be invaluable. How can one know if an 80m hub height is optimal in comparison to a 100m hub height, let alone a 160m hub height, without data at that level?

Quite often I find myself bewildered as I look at data. Isn't it ironic that an industry so concerned with precision of instrumentation is willing to overlook the most crucial data; the levels that are actually generating power? I have sat through numerous conferences where anemometer A is analyzed versus anemometer B to whatever degree of accuracy in order to determine if they are precise enough to be used for wind resource assessment. Later, another speaker will face the audience and say that no matter how much data we collect, we cannot be 100-percent sure of the wind speeds for a given site next year—there are so many climate related factors that we can only tell if it is a worthwhile site for the long run, he will say. With enough data, we can at best predict an average yearly speed, but we still cannot precisely predict the wind speed on a year by year basis. While we try to determine what the wind speed will be at a given level within 0.01 m/s—even when we know it probably won't be exactly the same next year—we are willing to overlook the phenomena that we know will happen annually: lower level jets, negative shear, onshore/offshore flows, etc. Talk about not seeing the forest for the trees.

I'm not suggesting that the precision of current instrumentation isn't valuable, but it would seem that knowing the data in the blade span of a turbine is equally valuable, if not more so.

Complexities to Consider

With a worldwide push to move to green energy, wind farms are growing at an increasing rate. While it is exciting to be part of this, it also means the most obvious locations for farms have probably been developed, or are being developed right now. Future farms will encounter new terrain, and with that new complexities. The need for blade span data has never been so great, and this will only continue to increase. If you were writing the check, after all, wouldn't you want blade span data?

A NEW DIRECTION FOR TURBINE GEARING

In this article Sandvik Coromant reports on tooling developments that are driving progress in cutting gears for wind-power components.

By Christer Richt

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EXPERIENCING GROWTH OF SOME 30 PERCENT per year, wind power manufacturing is undergoing an evolution. With several components being machining intensive, many processes are being reviewed, and new players from other manufacturing areas are bringing fresh ideas to how components can be made.

With gears being such an integral part of wind power generation, gear cutting is one of several component areas that are benefiting from new developments in machining technologies. Tool developments and design improvements that have been taking place for many years in other areas of manufacturing are now also benefitting the practice and performance of gear cutting.

Meeting Challenges

Wind power has to have gears and gearboxes, which means that a somewhat conservative industry is being challenged by new demands. With smaller component volumes for a new range of gears, even machinery is being reconsidered. Five-axis machining centers with new software are flexible enough to make different components—including gears, and even spiral bevel gears—to high accuracy. Although machining times are slower than those achieved with dedicated gear-cutting machines, setups are fast and the machines can also be used for machining related parts for gears, as well as other components for wind applications. This makes machining centers attractive for small-

to medium-sized series of gears. These types of machines are also what machine shops entering the wind manufacturing market already have in place.

To a growing extent, gear cutting for wind power is thus becoming a mix of the established, dominated by dedicated gear-cutting machines mostly using solid cutters, and the new, with a combination of different methods and equipment. Gear hobbing dominates as the method to efficiently machine gears, but with the growth of wind power a new mix of external and internal gears is needed, from large slew rings to smaller conventional gearbox wheels. This has made gear milling with single or duplex cutters and hobs that employ indexable inserts or blades an interesting alternative, and it is here that today's developments are making a difference in the economics of manufacturing.

Intensive Components

There is a leap in technology now occuring, where the recent tooling developments from other manufacturing areas are providing positive results for gear milling. Driven by competitiveness and the need for increased capacity, new modes of thinking with room for new tooling concepts have become a necessity in situations where parts require a lot of machining.

Large volumes of chips are generated in gear machining, with around 90 percent of the manufacturing processes involving metal cutting. This provides a huge potential for improvements in both productivity and production security, as well as quality consistency. The main driving trends in gear milling for wind-power components are: a move from solid cutters to indexable insert cutters; escalating cutting data, and a decrease in the use of coolant; growing application of disc cutters and hobs that can employ more effective teeth; the increasing use of duplex-type milling cutters and; one cut to an increasing extent replacing two cuts with a tool.

Solid cutters, usually ground and in high-speed steel, have dominated much of gear cutting, and they have the advantage of producing gears to within high tolerances. Their downsides, even after considerable tool material and coating development, is that machining rates are limited, durability is lower compared to cemented carbide, and there is a heavy reliance on the use of coolant. Generally, high-speed steel tools have a marginal application area in today's overall machining, and the share of gear cutting tools they hold is shrinking.

Cementing Concerns

Cemented carbide has a very advantageous combination of wear resistance and toughness, a combination which has been dramatically improved upon through the development of coated indexable inserts. Since coated inserts were introduced for milling during the eighties, research and development has made advantageous new means available for the large range of different milling operations and workpiece materials. During the past few years a completely new insert generation has been introduced for milling, built on new developments of insert substrates, coating materials, coating manufacturing, and post processes. There is no doubt that machine shops involved in most types of industry stand to benefit from adopting this new generation of inserts.

For many years coated inserts were dogged by cutting edges that, by necessity, were relative-

Fig. 1: Milling with a new generation of cutters and indexable inserts are providing higher performance capabilities to gear manufacturing. This indexable insert hob speeds up roughing of gears to higher accuracy levels for finishing.

ly blunt. The nature of the edge line was such that, if thicker multicoating layers were to be applied and then function, the edge radius on the insert had to be comparatively large. This phenomenon is outdated, to a large extent, in that both substrate and coating technology has moved on. New PVD-coated (physical vapour depostition) inserts have sharp, positive cutting edges with high edge-line toughness. Also, the original CVD-coating (chemical vapour deposition) that brought high wear resistance through chemical and thermal wear resistance to inserts with high insert-bulk toughness have been developed intensively, and in some application areas the two types of coated insert grades overlap and complement each other.

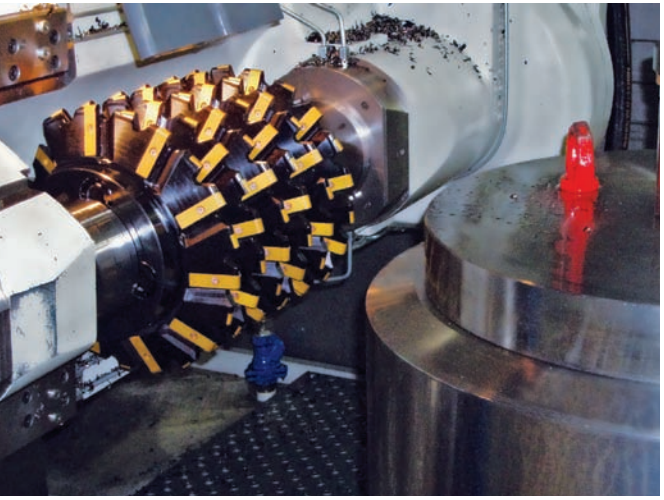

Fig. 2: This gear hob for roughing of external and internal gears is equipped with high-performance indexable inserts of CVD-coated grade GC4240. In one application involving a production of 1,000 planteray gears per year, the gear milling operation was improved through increasing the number of parts per insert edge by 35 %, adding higher security compared to the exisiting solution.

New Insert Generation

Two new-generation coated cemented carbide grades for indexable inserts in milling cutters have proved especially adaptable for gear milling. Large cutter diameters with many teeth used in alloyed steels of varying hardness need the right type of toughness, complemented by suitable wear resistance, to optimize an application. Gear milling creates it own type of toughness demands, in addition to that of the workpiece material, in that

Fig. 3: In an application involving the production of 200 slewing rings per year, new PVD-coated grade GC1030 increased the productivity rate by 30% through higher cutting data capability and higher machining security through advantageous wear development.

radial depths of the cuts are small, and cutter diameters are large. One PVD-grade GC 1030 and one CVD grade GC4240—both developed for high-performance steel milling with different cutter types—are now proving to be performance raisers for gear milling, with or without coolant. Depending upon the application and manufacturing priorities involved, these grades can be applied in order to:

- Raise cutting data;
- Lengthen tool life;
- Provide predictable durability for maintaining set quality levels;
- Secure continuous reliable machining, and;
- Reduce the per-piece cost of manufactured gears.

New technologies are entering the growing area of gear cutting, prompted by the requirements of the wind-power industry. The development of machine tools toward higher spindle speeds, and thus cutting speeds, in combination with higher stability, have opened up, allowing for cemented carbide to play a larger role. For many years tool developments have continually resulted in higher performance and lower machining costs in machine shops involved in aerospace, power generation, automotive, machinery, medical, and most other types of general manufacturing. Solutions for gear cutting dominated by solid cutters in dedicated machinery have been on the periphery of tool development. Today, with changing manufacturing patterns and broader product ranges, new tool concepts and methods are being introduced for gear cutting.

Cutting-Edge Tools

In addition to new gear-milling insert grades, special gear cutting disc milling cutters have been designed with newly developed gear flank and top indexable inserts. Inserts are being based on new insert-seat technology that locates and retains the insert in position, thus adding accuracy and security to the process. New duplex cutters with indexable inserts for simultaneous milling of two gear teeth for internal gear milling are raising roughing performance dramatically, as is the use of round insert milling cutters.

Based on long experience in developing and applying segment-based tools for crankshaft milling, cutters with segments holding new inserts will be introduced for disc and duplex cutters. Furthermore, for hobbing, solid cutter bodies with full-profile insert, along with segment hobs with tangentially mounted inserts, will provide a means of higher metal removal rates with long tool life. Also, new developments for cutting splines, gear racks, key slots, and for profile milling are taking place that will bring new levels of machining to gear cutting. Moreover, the finishing capability of indexable insert tooling is improving distinctly.

SOLVING THE TRANSMISSION DILEMMA

While transmission continues to be a major impediment to getting more wind power to the market, several important developments were made in the past few years.

By Paul Kaiser

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ACCORDING TO THE DEPARTMENT OF ENERGY (DOE), one of the primary challenges to getting more wind, solar, and other renewable energy projects developed is transmission. Transmission lines are needed to carry energy developed in sparsely populated areas of the Midwest and West to urban areas with higher population and higher energy demands. According to the February, 2009, "Green Power Super Highways" white paper, nearly 300,000 MW of wind generating projects were on hold to connect to the grid. The lack of transmission is not a newly created problem. The current situation is a result of inadequate investment in transmission in the 1990s. Investment during this period dropped to a low of $3 billion per year in 1999 (inflation adjusted). While that number has risen significantly, to $9.5 billion in 2008, development of transmission still lags behind a growing need. The North American Electric Reliability Corporation (NERC) warns investment needs to be increased and accelerated. In October, 2008, NERC projected that generation will grow by 21 percent while transmission miles will only increase by 9.5 percent. Furthermore, it warned, some areas may experience insufficient transmission reliability by 2010.

The causality dilemma of transmission exists because developers hesitate to move forward on generation projects without access to transmission lines, and transmission lines are seldom built without generation facilities with which

to hook up. Complicating the preexisting matter has been the recent increase in developing renewable energy projects. Many of these wind and solar projects, prompted by state-legislature passed RPS requirements, lack access to transmission lines to carry power to the demand. Twenty-eight states had enacted RPS standards by the beginning of 2009, and most of these require a specific percentage of electricity used in the state to come from renewable energy. In addition to the facilitative dynamics other hurdles also exist, including policy, who should decide on new transmission, environmental, ecological impact of where transmission lines are to be built, and financial—who will pay for new transmission?

> The causality dilemma of transmission exists because developers hesitate to move forward on generation projects without access to transmission lines, and transmission lines are seldom built without generation facilities with which to hook up.

While many states, utilities, and organizations struggle, some have found ways to move forward. Colorado, Texas, and California are all making progress by taking original and innovative approaches to these transmission issues. The following highlights come from a recently published report by the National Renewable Energy Lab detailing these efforts.

The state legislature in Colorado took two important steps in 2007 to overcoming these obstacles. First, it created a task force to recognize Renewable Resource Generation Development Areas (GDAs). These areas would be identified for having high renewable energy generating potential (at least 1,000 MW) but limited current transmission capacity. Similar to the state task force's GDAs, the legislature passed an additional bill in 2007 requiring utilities in the state to identify their own Renewable Energy Resource Zones (ERZs). Utilities were asked to create transmission plans to tap into these areas, and begin submitting applications for the development of new transmission lines. The utilities are required to conduct this review process every other year. Initially, the state taskforce identified eight wind-resource GDAs (total potential capacity: 96 GW) and two solar-resource GDAs (total potential capacity: 5.5 GW). Xcel Energy identified four ERZs and one transmission line project. The utility's findings were later expanded taking into account the work of the taskforce. Participating utilities "may recover transmission development costs during construction at the weighted average cost of capital, including a return on equity." (Schumacher, Fink, and Porter, 6.)

Similar to Colorado, Texas faces the transmission challenge as a result of both RPS regulation and geographic separation between resources and population. The Texas legislature passed an RPS increase in 2005, with a requirement of 5,880 MW of renewable energy by 2015. The bill also set a goal of 10,000 MW of renewable energy by 2025. The geographic challenge in Texas is due

to it having some of the greatest instate distance between high renewable resources in the West and high population centers (Dallas, Fort Worth, and Houston) in the east. A third challenge in the state also exists, in that the Panhandle and a portion of Eastern Texas are in different grids than the majority of the state. However, even with such great challenges officials in the state have pushed forward with a number of efforts. In 2005, Competitive Renewable Energy Zones (CREZs), similar to the GDAs and ERZs in Colorado, were developed by the state legislature. By 2007 the Electric Reliability Council of Texas (ERCOT) identified five of these high renewable energy generating CREZ areas in West Texas and the panhandle. ERCOT also produced several different scenarios for new transmission development. The most discussed scenarios were two and three. New transmitted energy ranged from 12,053 MW to 24,859 MW from these CREZ proposals. Cost estimates for the scenarios were published in April, 2008 and ranged from $2.95 billion to $6.38 billion. The Public Utility Commission of Texas (PUCT) granted preliminary approval for the second scenario at an estimated cost of $4.93 billion. The chosen scenario would provide 18,456 MW of wind power transmission (Austin Energy estimated one MW equal power usage of 750 homes, thus producing new renewable energy coverage for 13,842,000 homes). The transmission development includes 2,334 miles of new 345-kV line and 42 miles of new 138-kV lines. To finance this new transmission, costs will be spread across all load-serving entities in ERCOT. The reasoning for this is that when complete, new lines will become a part of the massive Texas-wide power grid. As an example, Austin Energy would be responsible for around $200 million, based on its 4 percent share of the ERCOT power load. Construction will be staggered over time with the first of these projects projected to be complete in 2011 or 2012. According to Paul Sadler, executive director of The Wind Coalition, Texas "has developed a process that will serve as a model for the country as we look to diversify our energy fuel mix."

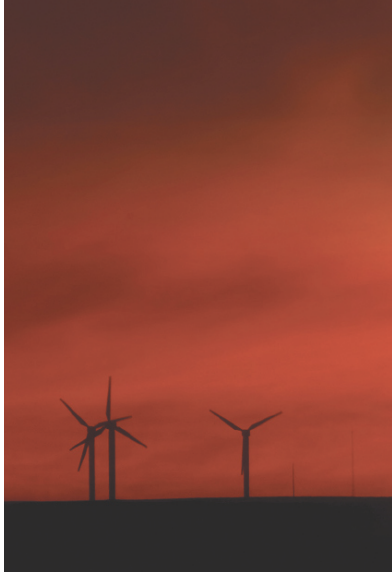
California faces a similar dual challenge with one of the most aggressive RPS standards in the country and great distance for transmission to cover. The state's legislature has passed a requirement of 20 percent renewable energy by 2010, and a goal of 33 percent by 2020. Experts both instate and nationally have recognized that transmission will be a primary obstacle, but this has not prevented at least two concurrent efforts to solve the problem. To overcome the challenges of financing new transmission lines in the state, the Federal Energy Regulatory Commission (FERC) approved an inter-connection tariff in December, 2007. This Location-Constrained Resource Inter-Connection Tariff (LCRI) will allow the California Independent System Operator (CAISO) to recover costs through a transmission access charge assessed to all loads on the grid. Once built, generators will begin paying a proportionate share of transmission costs. Most recently, in May 2009, CAISO announced that the board of governors has approved the first project. The Highwind Project transmission upgrade, which will eventually consist of 10 miles of new lines in addition to a new substation, has an estimated cost of $46 million. This project ranked fourth best in terms of environmental impact—seventh best in terms of economic—and was recognized as having the greatest potential energy output at just over 25,000 GWh per year.

Similar to efforts in Colorado and Texas, the California Public Utility Commission (CPUC), in conjunction with other regulatory agencies, launched the California Renewable Energy Transmission Initiative (RETI) in September, 2007. This effort aims at identifying Competitive Renewable Energy Zones (CREZs) both in-state and in neighboring states that require additional transmission to get online. The California RETI is structured in three phases. First CREZs were identified and ranked based on several factors including economic effectiveness, environmental impact, certainty of development, etc. The six-highest ranked CREZs had a combined in-state energy potential of nearly 75,000 GWh/yr, and out-state energy potential of 15,000 GWh/yr. The out-state CREZs were located in Oregon, Nevada, and Baja California Norte. The second phase of the effort involved further defining and refining conceptual transmission plans. New transmission lines were categorized as "Foundation," "Delivery," and "Collector." Proposed foundation lines increase overall capacity within the California network. Delivery lines would move energy from Foundation lines to major load centers. Finally, Collector lines connect the CREZ-areas to the Foundation and Delivery transmission lines. The total cost of the plan is estimated to be $6.5 billion.

In addition to state-focused efforts, there are also efforts happening between states and state and federal agencies. For example, the Bonneville Power Administration (BPA) is moving towards a new methodology for transmission. Historically, the BPA required power generators to provide all the upfront funding for new market-based transmission. However, the organization is now hosting "open seasons" where generators can submit projects to the BPA during specified time periods for consideration of funding assistance. Through this program the BPA has committed to provide new transmission service if it can be paid for at BPAs embedded cost rate and if BPA can meet the requirements of the National Environmental Policy Act (NEPA). The BPA is also willing to pay for initial engineering and design studies. During the first open season in 2008, 153 transmission requests were submitted by 28 participating BPA customers. Submitted projects represented nearly 6,500 MW. Following the open season submission period, BPA selected five projects enabling connection to 3,360 MW of generation (2,575 MW of which is from wind power). Total costs are estimated to be near

$800 million. Construction of the first project, the McNary-John Day 500-kV transmission line that will connect power to Seattle, Washington, and Portland, Oregon, began in spring of 2009. The project, which had previously been approved, but was on hold for lack of financing, is now being partially financed by the American Recovery and Reinvestment Act. When it goes online in 2012 it will provide transmission access for an additional 870 MW of energy (700MW of which is wind power). Recently, BPA held a second open season and received 83 transmissions service requests enabling nearly 5,000 MW of energy (2,599 MW of which were wind power).

In another example of innovative regional transmission strategies, the Southwest Power Pool (SPP)—which includes areas in Kansas, New Mexico, Texas, Oklahoma, Arkansas, Missouri, and Nebraska—identified a new approach for transmission service upgrades and development in 2007. The new tariff strategy was developed by the Power Pool's Cost Allocation Work Group (CAWG) and defining tariff language was approved by FERC in October, 2008. The methodology evaluates new transmission projects for inclusion into the planning process and allows the Power Pool to assign the cost of development and upgrades to all participating zones through a uniform per unit charge based on capacity consumed anywhere on the grid. The SPP aims to find projects that meet both "cost beneficial" and "balanced" benefits is the goal. "To meet the cost beneficial criteria, the sum of the net present value of total benefits must be equal to or greater than the sum of the net present value of total costs over a 10-year period. To be considered



balanced each zone must have total benefits greater than costs." (Schumacher, Fink, and Porter, 13) SPP has examined more than 50 potential projects to create a portfolio that adequately met both criteria. It has settled on five new 345-kV transmission lines totaling over 600 miles in Oklahoma, Kansas, Nebraska, and Missouri. The SPP will also build a new transformer in Anadarko, Oklahoma, and new connections between two existing 245-kV lines. The approximate total cost is estimated to be $700 million.

The NREL report closes with several conclusions for the successful development of transmission lines. First, it recommends creating transparent processes for identifying new transmission projects. The process should involve all stakeholders and information should be accurately distributed. Second, the report suggests that if new transmissions projects will be require to meet RPS policies, development and funding specifications should be included in RPS legislation. Thirdly, the report emphasizes the ben-

efits of identifying Competitive Renewable Energy Zones, like those in Colorado, Texas, and California. The report focuses on the benefits to identifying new regions with generation potential and transmission deficiencies prior to development of generation projects. Finally, the report supports the development of innovative cost allocation models, such as CAISO's pro-rata approach, for financing new transmission projects.

Additional information on all of these efforts can be found in the October, 2009, published NREL report "Moving Beyond Paralysis: How States and Regions Are Creating Innovative transmission Projects: May 2009-May 2010." Schumacher, A.; Fink, S.; Porter, K. (2009).

COOL SYSTEM, HOT RESULTS

New cooling system from Parker provides significant advantages to wind turbines by offering greater performance in a smaller package

By Dale Thompson

Dale Thompson is a business development manager within Parker's Advanced Thermal Solutions Business Unit and has pioneered the development of this next-generation cooling technology. For more information go to www.powersystemscooling.com.

THE UNITED STATES DEPARTMENT OF ENERGY has outlined a plan that would have wind energy provide 20 percent of the nation's expected energy requirements by 2030. The July 2008 report, titled "20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply,"[1] is a nearly 250-page document about integrating wind energy into the U.S. energy system. The document forecasts that, in order to meet this objective, wind power's 2030 output will need to be more than 300,000 megawatts, or 25 times greater than its 2006 output.

While the report comments on a variety of factors that will impact the viability of this accomplishment—including manufacturing, materials and employment, transmission and integration, siting and environmental effects, and markets—significant emphasis is placed on wind turbine technology. The report states that "continued technological advancement would be required under the 20% Wind Scenario."

While much of the current industry's efforts are being directed toward developing better rotor control mechanisms, new blade materials, more-aerodynamic shapes, and electrical SCADA (supervisory control and data acquisition) systems, another area where significant gains can be made involves cooling of the advanced electronics being used to convert and transmit the generated power to the grid. To facilitate this process, engineers at Parker's Advanced Thermal Solutions Business Unit have developed a two-phase cooling system

said to be the world's first commercialization of pumped two-phase cooling technology, and one that is ideally suited for the demands particular to wind turbine power generation.

The Enemy Within

Excessive heat is counterproductive to wind-generated power, and there are a number of possible sources from which it can develop. At its most basic level, wind power is all about motion: converting the linear force of the wind into rotary motion. Basic physics tells us that where there is motion, there is friction, and where there is friction there is heat. Excessive heat causes lubricants to break down and materials to expand, which in turn causes more friction and heat, leading to frequent lubricant replacement and gearbox repair. Further, the increasing use of permanent magnet generators is also not conducive to heat, as standard grades of magnets have a Curie point—the temperature at which they become demagnetized—of as little as 176° F (80° C).

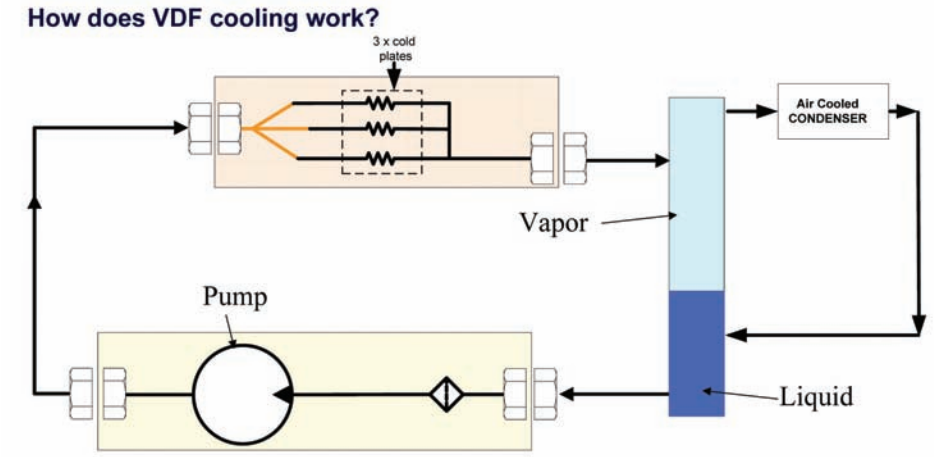
Design engineers typically rely on air-cooled systems to address the mechanical heat generated. Such a cooling system often involves pumping the lubricating oil through a radiator/fan cooling unit and then dissipating the heat to the outside ambient air. Electronics are also a major heat source, and wind power's consistent variability only exacerbates matters.

The conversion of variable linear motion into consistent power suitable for the grid is accomplished by a series of switches called Insulated Gate Bipolar Transistors (IGBTs). These devices convert the direct current from the turbine's generator into alternating current for the grid by generating an artificial sine wave. In this function, the more frequently the switch is turned on and off, the closer to a true sine wave the current flow becomes, and the more sine-like the flow, the purer the power. However, the faster the switch actuates the more heat it develops, and given a wind turbine's variable inputs, IGBTs for this application need to cycle very frequently, generating large amounts of heat that will dramatically decrease overall efficiency unless properly cooled.

Design engineers have traditionally turned to water cooling for the electronics applications. Water cooling offers some decided advantages over air cooling, but it too has some severe drawbacks. While more effective than air as a heat exchange medium, water is conductive. In the event of a system leak the system's effectiveness would not only be compromised, but water entering an electronic device could easily cause a short, damaging—if not destroying—any electrical equipment with which it comes in contact, such as controllers and sensors.

In addition, water is prone to thermal stack-up, where water flowing from one cooling element to another picks up heat, providing less cooling as it flows. While very effective at cooling early in a closed-loop system, by the time the water reaches cooling elements further downstream, the amount of heat that the water can absorb decreases relative to the heat it has already taken on upstream. Inline cavitations can be frequent issues in rapidly flowing water-based systems. Cavitations tend to occur where inline pressure at various points in the line cause a fluid to vaporize into a gas bubble. Upon pressure equalization the bubble suddenly collapses, releasing a burst of energy that can damage the system.

Water's freezing point poses a problem as well, as it is not uncommon for wind turbines to be sited in areas where temperatures routinely drop below the freezing point. The standard approach to freeze



VDF cooling loop with a pump, three cold plates and air cooled condenser.

prevention is the addition of ethylene glycol to the water. While this helps prevent the freezing, it also reduces overall thermal performance. To compensate system engineers are forced to choose larger, more-expensive IGBTs, which then need to run more slowly so as to not generate too much heat.

Parker's new Vaporizable Dielectric Fluid (VDF) system provides better heat transfer capabilities than both air- and water-cooled systems without any of the associated disadvantages. It also offers the added benefit of a significantly reduced footprint requirement; the company claims its system will provide twice the cooling capacity in half the size or less than comparable air- or water-cooling systems, in fact.

Theory of Operation

Part of the beauty of Parker's new VDF cooling system is the simplicity of its operation. Key components of the closed-loop system include the dielectric fluid, liquid cold plates, and a low-flow-rate pump. Noticeably absent from this system is a compressor.

Dielectric Fluid: While most VDFs are suitable, Parker selected R134a, as it is a commonly used refrigerant found in most refrigerators and automobiles, is fully dielectric, flashes to gas at ambient temperatures, does not react with metals and is intrinsically harmless. Newer fluids are being developed that have similar characteristics but better global warming ratings. Such fluids are expected to be a drop-in replacement.

Liquid Cold Plates: Typically designed for the component that will rest on top of it, cold plates are usually made from aluminum or copper. Unlike water-cooled systems, a VDF cold plate may be made from metals different from other parts of the system, as VDFs do not cause galvanic reactions. This feature allows for lower-cost cold plate fabrication, as such plates may be made from a wider variety of metals, including lower cost and/or more easily machined and brazed metals that would be subject to galvanic reaction in a water-based system. The direct contact between the plate and the heat-generating device allows for latent heat transfer, with the heat being carried away by the vaporizing fluid traveling through the plate. Multiple cold plates may be built into the system either in series or parallel to accommodate different components within the device.

Low-Flow-Rate Pump: Specially adapted from pumps Parker had developed for aerospace and automotive applications, the unique hermitically sealed pump employs the gear-pump method of flow management, where a turning gear within the pump's body uses displacement to create flow and suction to move the fluid. The pump moves the fluid as a liquid through the loop at a pressure just below the levels where, at ambient temperature, the fluid would flash to gas. As it enters the cooling plate the fluid absorbs the heat from the component, causing some fluid to vaporize. The amount of fluid that vaporizes is directly proportional to the amount of heat to be transferred, which is then taken downstream in a two-phase liquid/gas mixture and away from the component, as illustrated above.

An important characteristic of this system is that the pressure and temperature are allowed to "float" relative to the electrical "work" being performed by the IGBTs. As the workload increases (i.e., amount of switching), the heat load rises causing the amount of vaporization within the cold plates to increase. As the workload diminishes, the vaporization reduces. This is a nearly instantaneous occurrence that does not require sensors and control systems, making it inherently self-optimizing.

Another important characteristic of the VDF system is its isothermal nature, where every cold plate's temperature is roughly the same regardless of where it is in the system, as the vaporization

temperature is constant while the amount of vaporization is variable. This feature eliminates the thermal stacking issues to which water systems are prone.

System Advantages

Parker's new two-phase liquid cooling system offers a number of distinctive benefits. VDF heat transfer efficiency is significantly greater than water, requiring less fluid, smaller line sets, and lower pump rates. The same dissipation rates provided by a 6 liters/minute water flow can be achieved by 1 liter/minute VDF flow, allowing for a smaller system. Further, the low-flow nature of a VDF system virtually eliminates the possibility of inline cavitations and corresponding potential damages.

A smaller pump also consumes less power, which can be parasitically drawn from the system it is cooling rather than its own power source, which helps free more area. The system is virtually maintenance free. The VDF is non-corrosive, requires no filtering, and is not subject to freezing. The low-power pump utilizes a brushless DC motor rated to provide 50,000 hour L10 continuous-duty life. The hermetically sealed assembly is designed to be leak proof, but should a leak occur the non-conductive fluid will not damage any electronic components. Dry-break connectors make for easily field-replaceable modules needing minimal or no device downtime for scheduled maintenance or failure replacement. The cooling system's inherent efficiencies and lack of thermal stack-up provide an additional advantage in that the system maintains a fairly tight temperature range. This lack of thermal cycling removes a strain on the turbine's electronics, thusly extending their useful life.

While these advantages are significant, VDF cooling systems also open more area in which design engineers can do their work. VDF cooling units will not only provide more cooling than water units twice their size, VDFs more-efficient cooling lets the design engineer shrink the power electronics package, allowing for not just a smaller cooling system but a smaller electronics management system.

This new cooling system has been developed by Parker's Advanced Thermal Solutions Business Unit drawing on core competencies of several of the company's divisions, including aerospace, electromechanical, flow control, refrigeration, and tubing and fittings. Featuring a number of proprietary and patent-pending elements, the first commercial applications of this new technology began to go online in June of 2009.

Reference:

1) DOE/GO-102008-2567, www1.eere.energy.gov/windandhydro/pdfs/41869.pdf

FREE MONEY FOR WIND DEVELOPERS

Allow these experts to guide you through the grant funds available to wind developers through The American Recovery and Reinvestment Act of 2009.

By Jessica A. Graf and Justin B. Mead

Jessica A. Graf and Justin B. Mead are with Greenberg Traurig LLP. She can be reached at grafj@gtlaw.com, and his e-mail address is meadj@gtlaw.com. Go online to www.gtlaw.com.

THE AMERICAN RECOVERY AND REINVESTMENT Act of 2009, or "ARRA," added two new and significant provisions, enacted as part of an effort to spur domestic development and installation of renewable energy, that are available to developers to help finance their wind projects.

The first provision permits the wide range of renewable energy facilities that qualify for the federal production tax credit (PTC) under Section 45 of the Internal Revenue Code (the "Code"), including those powered by wind energy, to claim the federal investment tax credit (ITC) under Section 48 of the Code in lieu of the PTC. While the PTC is based on the amount of electricity produced and sold to an unrelated person during the 10-year period beginning on the date the facility is placed in service (currently at the rate of 2.1¢ per kWh of such electricity for wind), the ITC is a one-time credit claimed in the year the facility is placed in service that is generally equal to 30 percent of the cost of the renewable energy facility.

The second provision created a new program that enables PTC-eligible and ITC-eligible facilities to receive a cash grant from the Treasury (the "Grant") in lieu of the PTC or the ITC, in an amount generally equal to the amount of the ITC that would otherwise be available to the facility. The Grant is designed to be paid out faster, and to be claimed more conveniently by developers, than traditional tax credits.

Two notices were recently issued by the federal government establishing the procedures that must be followed to qualify for and claim these incentives. Specifically, in June 2009 the IRS provided guidance for taxpayers wishing to claim the ITC in lieu of the PTC; and in July 2009 Treasury issued guidance for applicants who decide to claim the Grant in lieu of the PTC or the ITC.

Claim Choices

Initially, an owner of a renewable energy project eligible for the PTC, such as a wind facility, must determine whether the expected benefits of the PTC are more or less than the benefits of the ITC or Grant. This requires a consideration of various factors. While the PTC requires a sale of electricity to an unrelated person, the ITC and the Grant do not, so an "in the fence" project—the output of which will be used by the owner—cannot claim the PTC unless the ownership and operation of the project is restructured. In addition, a financial model should be developed to get a clear picture of the net present value associated with the PTC versus the ITC and Grant, which will depend on various factors including the cost, capacity rating, and the net capacity factor of the project. The model should also reflect the fact that the ITC and Grant both require the owner to reduce the basis in the project by an amount equal to 50 percent of the ITC or Grant, thus reducing the amount of depreciation that may be claimed with respect to the project (the PTC does not require any basis reduction), and the fact that the PTC must be reduced (up to 50 percent) by the percentage of total project basis that is funded by tax-exempt or government-subsidized financing (while the use of such financing no longer requires any reduction to the ITC or the Grant).

Any decision to take the PTC must also consider the ability of the owner to utilize or otherwise recognize the benefit of a tax credit. Because developers often operate at a loss in the early years during project development, the Grant may offer the potential to recognize value that may not otherwise be available, at least in the absence of the implementation of a complicated and costly "tax equity" structure. This is especially significant in the current financial environment, which has seen a dramatic decline in the availability of tax equity finance for wind energy projects. Other factors that should be considered include the production (and thus value) risk inherent in the PTC and liquidity concerns, as recapture of the ITC may be required in the event of certain transfers.

If, after an analysis of the relevant factors, the owner of a renewable energy project decides to claim the ITC or Grant in lieu of the PTC, it has the option of either: 1) making an election to claim the ITC pursuant to the procedures set forth in IRS Notice 2009-52 (the "Notice") or; 2) claiming the Grant pursuant to the guidance issued by the Treasury pursuant to Section 1603 of the ARRA (the "Grant Guidance"). While the Grant may often be preferable where the owner cannot utilize a tax credit, simply claiming the Grant and letting the accelerated depreciation deductions go unutilized would leave a present value benefit on the table that nearly equals the ITC or Grant amount. In an effort to recognize the benefit associated with these deductions, the owner may pursue a monetization structure with part or all of the project owned by a tax equity investor. In this case the tax equity inves-

tor may prefer the ITC over the Grant for accounting or other reasons.

As illustrated here, the decision to claim the PTC, the ITC, or the Grant is a complicated one that should be based on a detailed analysis of various factors. Accordingly, we highly encourage owners of renewable energy projects to consult legal counsel before choosing which path they will take. The requirements and procedures set forth in the Notice and the Grant Guidance will now be addressed.

ITC/PTC Considerations

To claim the ITC for a wind facility, a taxpayer must file a completed Form 3468—available at www.irs.gov/pub/irs-pdf/f3468.pdf—with the taxpayer's income tax return for the year in which the wind facility is placed in service (which occurs once the facility is ready and available for its specific use). In addition, a statement containing the following information must be submitted with the Form:

1) The name, address, taxpayer identification number, and telephone number of the taxpayer;
2) A detailed technical description of the facility, including generating capacity;
3) A detailed technical description of the energy property placed in service during the taxable year as an integral part of the facility, including a statement that the property is an integral part of such facility;
4) The date that the energy property was placed in service;
5) An accounting of the taxpayer's basis in the energy property;
6) A depreciation schedule reflecting the taxpayer's remaining basis in the energy property after the ITC is claimed;
7) A statement that the taxpayer has not and will not claim a Grant for property for which the taxpayer is claiming the ITC;
8) A declaration, signed under penalties of perjury, that the taxpayer has provided, to the best of its knowledge and belief, true, correct and complete information on the Form 3468 and the accompanying statement.

The Notice also requires the taxpayer to maintain adequate books and records, including with respect to the above-delineated information that is submitted with Form 3468 and all supporting documentation.

While the Notice provides guidance on how a taxpayer may elect the ITC for certain PTC-qualified energy property, the IRS

has not addressed all the relevant details. For example, no definition of "facility" is provided, nor is any definition provided for what constitutes property "integral" to a qualified facility. As a result, the IRS might determine, for example, that each wind turbine constitutes a "facility" for this purpose, or it might consider the entire wind farm to constitute the "facility." Furthermore, the Notice does not delineate what each taxpayer must provide to satisfy the "detailed technical description" requirement.

Grant Claims/Guidance

The Grant Guidance specifies the types of property included in a renewable energy project, the costs of which may be taken into account in determining the Grant amount (such property, "Eligible Property"). Many of the rules set forth in the Grant Guidance depart from those applicable to the ITC, including the rules relating to the property that may be taken into account, and often in a manner that is materially favorable to a developer or applicant.

Applications may be submitted online at www.treasury.gov/recovery and must contain supporting documentation such as design plans, final engineering design documents stamped by a licensed professional engineer, and documents establishing nameplate capacity. An applicant has the option of filing a single application for each grouping of Eligible Property that is functionally interdependent—e.g., each wind turbine together with its tower and pad—or for multiple groupings of interdependent Eligible Property that are part of a single project and located at the same site: e.g., a wind farm. In the latter case, an applicant that cannot complete construction of the wind farm before January 1, 2013, may still apply for the Grant for the Eligible Property that has been placed in service prior to that date.

The Grant will be paid to approved applicants within 60 days from the date the completed application is received by Treasury or, if later, the placed in service date. All payments will be made via electronic funds transfer no later than five days from the date notice of approval is given. The Grant is generally not includible in the income of the recipient. However, as is the case with the ITC, an election may be made by a lessor of a renewable energy project to allow the lessee to claim the Grant; while no reduction to the basis of the project is required as a result of this election, the lessee must agree to include 50 percent of the Grant amount in income ratably over the ensuing five-year period. Furthermore, the lessor and lessee must agree that the lessor waives all rights to receive the Grant, the PTC, or the ITC with respect to the Eligible Property. The election is made by a written agreement between the lessor and the lessee that contains specific information delineated in the Grant Guidance. This agreement must be included in the lessee's Grant application. The election is irrevocable and may be made with respect to each Eligible Property leased by the lessor to the lessee.

Eligible Property must be placed in service between January 1, 2009, and December 31, 2010, regardless of when construction begins, or placed in service after 2010 and before January 1, 2013 for wind projects, provided that

construction of the Eligible Property begins in 2009 or 2010. Construction begins for this purpose when "physical work of a significant nature begins," and a safe harbor is provided pursuant to which such physical work will be deemed to have occurred when the applicant incurs more than 5 percent of the total cost of the Eligible Property, excluding the cost of any land and preliminary activities.

Generally, governmental and tax-exempt entities, and pass-through entities that have a governmental or tax-exempt entity as a direct or indirect owner (each, a "Disqualified Person") are ineligible for the Grant; however, a taxable "blocker" C corporation may be created to qual-

WIND SYSTEMS

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ify. Only owners and, if certain conditions are met, lessees of Eligible Property are able to apply for the Grant. Applicant eligibility is determined as of the time Treasury receives the application.

The basis of Eligible Property on which the Grant is calculated is determined in accordance with the general rules for establishing the basis of property for federal income tax purposes. Costs that will be deducted for these purposes in the year in which they are paid or incurred are not includible in the basis. Applicants must submit with their Grant application documentation to support the cost basis claimed for the Eligible Property, including, in the case of projects with Eligible Property that has a cost basis in excess of $500,000, an independent accountant's certification of such basis.

A certain percentage of the Grant must be recaptured if, within the five-year period beginning on the date the Eligible Property is placed in service, either the Eligible Property ceases to qualify as Eligible Property—which may occur as a result of becoming used predominantly outside the U.S. or if there is a permanent cessation of energy production from the property, other than due to natural disaster—or the Eligible Property is sold and a Disqualified Person becomes a direct or indirect owner of the Eligible Property, other than through a taxable C corporation. The recapture percentage declines ratably in 20 percent increments, from 100 percent if the recapture event occurs in year one, to zero percent if the recapture event occurs after year five. Amounts subject to recapture are not considered tax liabilities but rather constitute debts owed to the U.S. collectible by all available means against assets of the applicant, including enforcement by the U.S. Department of Justice.

The Grants should prove helpful to many wind developers, especially in the current economic climate where capital is scarce and generally attainable only by paying large returns. There are several requirements that must be satisfied in addition to those described here; as a result, applicants are encouraged to consult with counsel before submitting an application.

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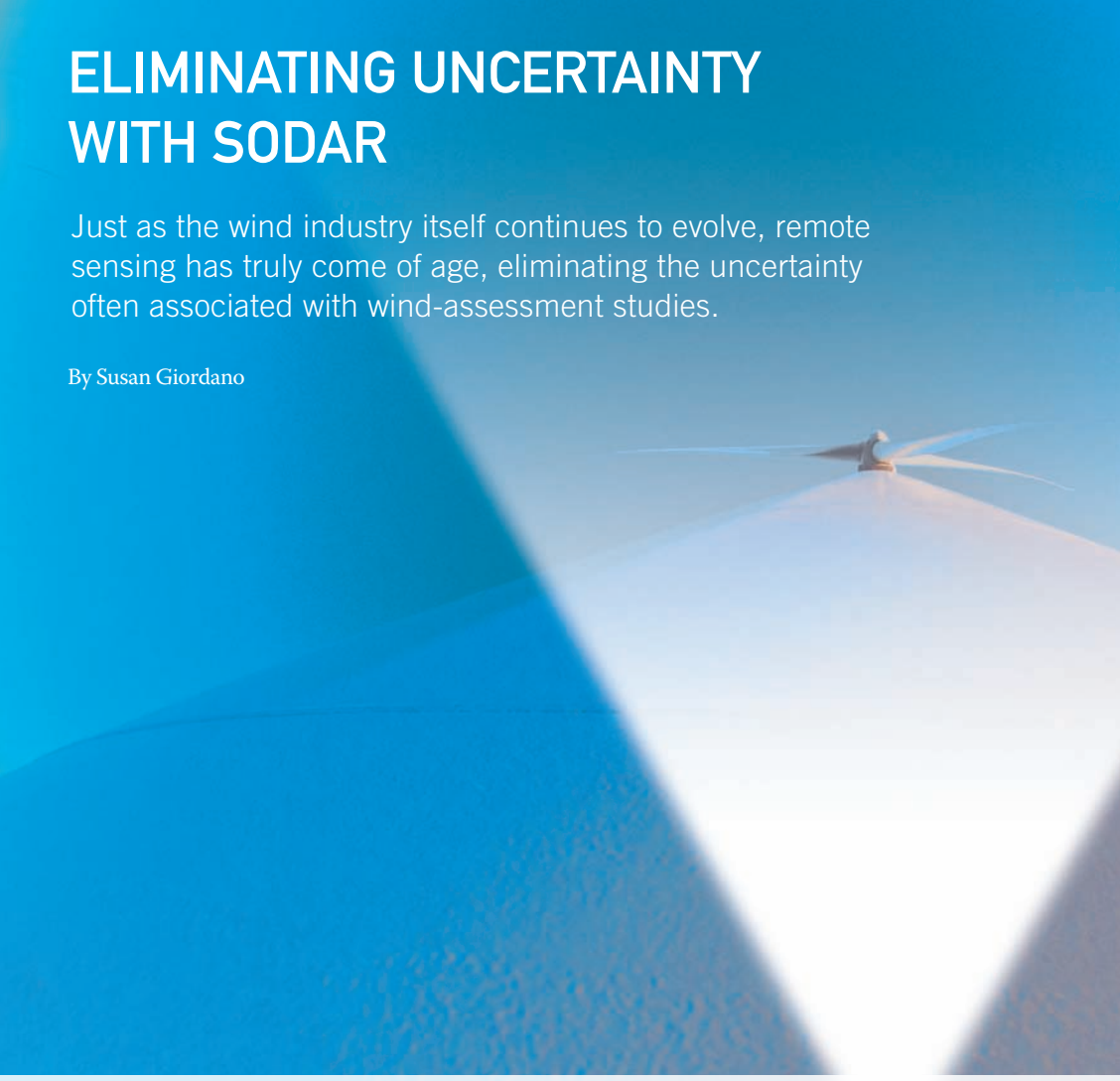
ELIMINATING UNCERTAINTY WITH SODAR

Just as the wind industry itself continues to evolve, remote sensing has truly come of age, eliminating the uncertainty often associated with wind-assessment studies.

By Susan Giordano



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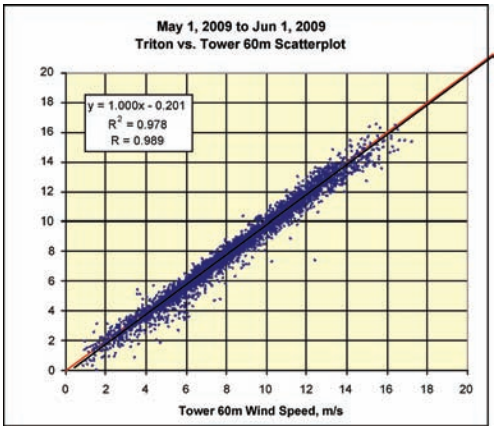
AS THE WIND ENERGY MATURES, project developers and financiers are asking for more-accurate predictions of power performance. Remote sensing systems including sonic detection and ranging (sodar) and laser imaging detection and ranging (lidar) are gaining currency as a way of measuring wind at the higher heights demanded by today's utility-scale wind turbines. As remote sensing gains currency and has a track record of being deployed in many locations worldwide, the industry has developed a greater understanding of how advanced wind characteristics affect power performance. This article provides an overview of some of the commercial applications of sodar.

Sodar has been used commercially by the wind industry in the 1980s for micrositing, and more recently for wind resource assessment. Recent advances in sodar technology have improved the accuracy and reliability of sodar systems, and sodars have been gaining wider acceptance since 2007.

In 2008 Second Wind, Inc., introduced an advanced sodar system, the Triton™ sonic wind profiler, in the United States. Since that time Tritons have been installed by leading wind energy developers in North America, France, Spain, Italy, Eastern Europe, and Australasia.

Accuracy is the key requirement for acceptance of a measurement technology. Historically, remote sensing systems have been compared with anemometry, which creates some challenges for comparison. Lidar systems can be placed

directly under a met tower, which makes correlation a simpler matter. Because of the possibility of fixed echoes—echoes that bounce off of non-moving objects and generate false data if not accounted for—a sodar must be placed at least one tower height from the tower. Sound waves produced by the sodar can bounce off of the meteorological tower or other objects in the environment, creating false readings. Even with filtering of the data to eliminate tower shadow and flat terrain, since the wind is an unseen force, slight but measurable variations may occur over the 60-200 meters that will reduce the correlation coefficient. However, modern sodar systems—when properly sited and with appropriate data filtering—will correlate with an-



emometers at about 0.98 (see scatterplot graphic for an example).

Sodar, like anemometry, can play three basic roles in the life cycle of a wind project:

1) *Wind prospecting:* The quick deployment of sodar systems makes them appealing for prospecting, to determine if an area merits further study as a wind site;
2) *Resource assessment:* The ability of sodar to measure higher heights at a lower cost makes these technologies useful for resource assessment and the development of project energy estimates;
3) *Operations and maintenance:* The portability of sodar systems allows them to be used in gathering strategic wind data on an operating wind farm to assess operations and predict maintenance needs.

Wind Prospecting

Sodar systems are finding favor with wind developers and community wind groups who want to quickly assess the wind potential at a site. They may be validating local conditions against a mesoscale map, or determining whether and where to place met masts. The rapid deployment and mobility of sodar systems gives them a significant advantage over met masts in this application; they are also much more readily deployed than lidar systems because of their lower power requirements.

Candidate sites used to be chosen by referring to historical data, which were usually collected only up to 30 meters, combined with subjective site evaluations. With a rapidly deployable, portable remote sensing system, six or seven sites can be prospected during a period of six months with measurements at heights of 50-200 meters. (ref: www.windwire.blogspot.com/2009/04/sodar-based-wind-measurements-for.html). By rapidly eliminating sites over a short period of time, wind developers can make a quicker and better choice of a candidate site for a lengthier resource assessment study.

Wind Resource Assessment

A wind resource assessment study is one of the most important components of a wind farm development project. The study results in power performance projections, which determine project financing. The higher height data provided by sodar allows a greater understanding of the wind resource across the area swept by the turbine's blades.

Expanded use of sodar in wind resource assessment has been made possible by the technological improvements in sodar, especially the increased accuracy and reliability. Developers are still using remote sensing in conjunction with met masts, but the length of deployment of the remote sensing system has increased from days or weeks to months. Typically a complete wind resource assessment study is conducted during a period of 12 months so that the wind resource can be measured during all seasons of the year.

Where third party financing is not required, complete project assessments have been performed only with sodar, in conjunction with historical data and modeling. However, as of this writing, leading bank engineering firms do not accept sodar data exclusively for energy assessments.

Remote sensing will only replace the met mast when the accuracy has been accepted over a wide range of site conditions, and when remote sensing systems are able to operate unattended, in all weathers, on minimal power, the way met mast systems are. Once those criteria have been met, wind developers will embrace the portability, small footprint, and low profile.

Relying on actual measurements of the wind speed at different heights, rather than extrapolating the speeds at higher heights using estimated shear exponents, allows more accurate predictions of turbine power performance. A trend toward underperformance of wind farms based on anemometry data is calling attention to the promise of sodar (and lidar) as predictors of power performance.

In addition, measuring the number and extent of shear events—short periods of extreme differences in wind speed or wind direction at different heights—can allow for a better understanding of the resource suitability. Shear is thought to contribute to wear and tear on the turbine, and the evaluations of a wind resource assessment study using higher height data can be used to help choose the proper type of turbine.

Micrositing was the first application of sodar in wind development, and sodar continues to make a strong contribution during this phase of project development. Although many factors must be considered when placing turbines in a wind farm layout, understanding localized variations in the wind resource will help refine energy projections and identify locations with higher shear or turbulence.

Operations and Maintenance

Before the use of portable sodar systems, wind farms often operated with just one or two met towers for reference. Once the turbines are installed, more and better wind data is needed to understand why the turbines perform as they do and as an aid to operations and maintenance. The ability to move a sodar system around on an operating wind farm gives wind farm operators access to strategic wind data that they can use to assess their operations and help predict maintenance needs.

Operators are also beginning to use information from sodar systems to provide information to forecast models. In some markets, accurate forecasts are key to maximizing revenues. More turbine hub-height wind data can enhance the quality of forecasts.

Considerations in Evaluating a Sodar System

When evaluating a sodar system, check the manufacturer's specifications regarding:

- *Power requirements.* For operation in remote locations, a system with low power needs that can be met by a few solar panels offers a higher degree of autonomy. Remote sensing systems that require relatively large amounts of power may require an auxiliary power supply system.
- *Operation in various types of weather*, and whether the manufacturer has developed algorithms to account for rain.
- *Correlation to anemometry.* How many studies have been completed to compare the remote sensing system to tower-mounted anemometers, what is the correlation, how long have the studies been carried out for, and how many heights have they been correlated at? A correlation coefficient of approximately 0.98 to anemometry measurements improves confidence in the remote sensing data.
- *Field serviceability.* If the sodar system fails, can it be repaired in the field or does it need to be returned to the manufacturer?
- *Amount of experience* in wind site assessments. How many units have been deployed, for how long, and what is the equivalent number of years of operating experience?

Conclusion

Used either as a complement to met tower data or as a standalone tool, remote sensing systems are finding broader application in wind resource assessment programs and are also being used throughout the lifecycle of a wind farm. This game-changing technology is helping wind farm developers and financiers reduce the uncertainty of wind resource assessments, micrositing studies, and wind farm operations, thus further improving the viability of wind as an energy source.

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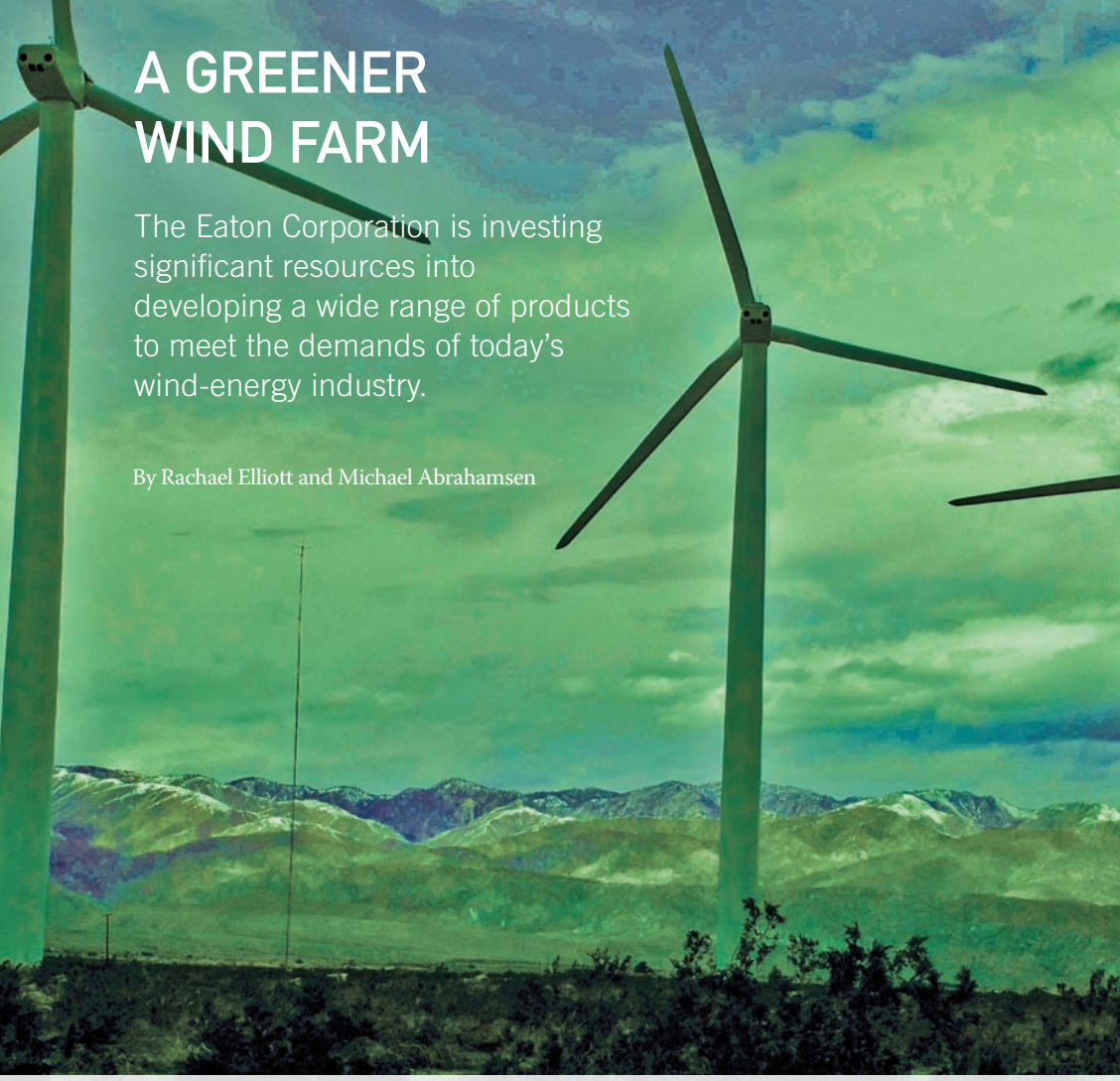
A GREENER WIND FARM

The Eaton Corporation is investing significant resources into developing a wide range of products to meet the demands of today's wind-energy industry.

By Rachael Elliott and Michael Abrahamsen



Rachael Elliott and Michael Abrahamsen are with the Eaton Corporation. For more information go online to www.eaton.com.

THE DESIRE FOR MORE EFFICIENT, cost-effective, and environmentally friendly power generation continues to grow exponentially. Recently the U.S. Department of Energy (DOE) published a paper that examined the potential of increasing wind generation to 20 percent of the generated electricity in the United States by the year 2030, boosting the current production capacity of 16.8 gigawatts (GW) to 304.0 GW.[1] Clearly, an increase of this extent would have dramatic impacts in technology, manufacturing and power transmission, in addition to the potential effects on the economy and the environment. To the goal of the DOE, one of the largest results of this initiative is the dramatic reduction in greenhouse gasses that are produced by the electricity sector from the burning of fuels that generate electricity.

In order to take advantage of wind to cleanly generate electricity, there are quite a few challenges that the electrical sector must address and overcome. Electrical equipment chosen for wind farm applications usually has extreme operating conditions and requirements, due to the fact that these systems tend to be located in remote areas with harsh environmental conditions. The electrical equipment must be able to withstand the surrounding environment, require little to no routine maintenance, and be very reliable. It is not practical to make frequent trips to a wind farm for routine maintenance or quality issues, and nuisance outages

Fig. 1: Front-accessible SF_6 free switchgear.

due to faulty equipment are unacceptable and expensive. Space challenges are also a major issue to overcome when designing the electrical distribution system of a wind farm. In addition to the generating turbine, a windmill tower is often required to house a complex collection of electrical equipment to collect, manage, and distribute the electricity that is generated. With limited space in the base of a windmill, it is critical to utilize very compact distribution system components.

Because of the need for compact electrical systems in wind farms, some installations include gas-insulated switchgear (GIS) for systems with voltages from 5,000–38,000 volts. GIS uses sulfur hexafluoride (SF_6) gas as their primary means for electrical insulation. SF_6 GIS is known for being extremely compact in size, which makes it functional for the space-saving needs for wind-generation applications. Since the 1950s the U.S. electric power industry has used SF_6 widely in circuit breakers, GIS and other switchgear used in the transmission system to manage the high voltages (>38kV) carried between generating stations and customer load centers, but for systems with voltages below 38000V there are plenty of options available to meet power distribution needs without the use of SF_6 gas for insulation. At a glance, SF_6 systems or medium voltage GIS systems seem to be the perfect solution to the problems presented by the wind power application for electrical equipment, and as a result some engineers have begun to select medium voltage GIS for use in the wind power market.

Gas-insulated switchgear is not without its problems, however. It is important to note that SF_6 is the most highly potent greenhouse gas that is classified by the Environmental Protection Agency (EPA) to contribute to air pollution that potentially endangers public health and welfare. The electrical power industry uses roughly 80 percent of all SF_6 produced worldwide. Ideally,

Fig. 2: Fixed-mounted components, such those found in Eaton's MSB, provide increased reliability.

none of this gas would be emitted to the atmosphere. In reality, however, significant leaking occurs from aging equipment and gas loss occurs during equipment maintenance and servicing. With a global warming potential 23,900 times greater than CO_2 and an atmospheric life of 3,200 years, one pound of SF_6 has the same global warming impact of 11 tons (or 22,000 lbs) of CO_2. In 2002, United States SF_6 emissions from the electric power industry were estimated to be 14.9 T_g Co_2 Eq.

Thus, while wind-generated electricity can have a large positive impact on the quality of the atmosphere by the reduction of CO_2 emissions, the use of SF_6-insulated electrical equipment in wind installations could be counterproductive to this goal. A wind farm cannot be considered "green" if it is exhausting greenhouse gases while generating electricity. Therefore, for a wind farm to produce actual clean energy, it should not rely on electrical equipment that uses SF_6 as an electrical insulation. Unfortunately, there is a lack of education regarding the dangers of SF_6 and a lack of awareness of the alternatives to gas-insulated switchgear that are available for use in compact electrical installations.

There are other aspects to consider, as well. For instance, SF_6-insulated switchgear is sealed and pressurized, thus they are typically viewed as low maintenance. Additionally, the SF_6 systems are generally comprised of switching devices that are bolted into place. This fixed-component design is often seen as an enhancement to reliability. When considering how these factors can be seen as solutions to the challenges for electrical components in wind installations, it is no wonder why these gas-insulated installations have sometimes been the product of choice for wind power generation applications.

As the industry becomes more knowledgeable, however, it is becoming apparent that there are obvious difficulties in maintaining a pressurized, sealed system and handling a potentially hazardous gas. It is also apparent that reliable fixed-component systems—available in many different configurations with and without SF_6—may prove to be difficult to work on if there is ever an issue. The components in any fixed component system cannot be easily accessed or removed for maintenance, and if there is SF_6 gas used for insulation the removal or replacement of a component is both more difficult, and more hazardous to the environment.

To this end, Eaton—a global power distribution company—has committed to providing the most compact medium voltage electrical products in the market without the use of any materials that could have potentially harmful side effects to the environment. Eaton has a full range of medium voltage electrical distribution products that provide ideal space-saving solutions for wind farm applications without the use of SF_6 gas as an insulator.

Insulation systems that utilize a combination of solid insulators, normal air, and engineered

current-carrying components can provide a homogenous barrier between the environment and the critical current-carrying components, in addition to adequate air clearances to prevent any dielectric breakdown. A variety of electrical systems with fixed-mounted components—such as Eaton's MSB, Innovac MMS, and Xiria—are available to provide the reliability of bolted-in components for those that shy away from withdrawable circuit protection. There are also a variety of electrical systems that combine solid insulation, air clearance, and withdrawable elements, such as Eaton's MEF, Innovac SVS, AMPGARD® and medium voltage variable frequency drive. These systems provide very high reliability in addition to reduced installation, maintenance time, and costs. By having the ability to reduce the maintenance cycle with withdrawable components that can be easily removed and replaced, downtime can be greatly minimized.

Remote-monitoring systems like GearGard® and InsulGard™ are available from Eaton, and they can provide a customer with real-time information about the operating conditions of the equipment, including temperature, humidity, and insulation health. These systems can monitor a customer's electrical system, send periodic current system health statements to a customer, and even predict a potential issue far enough in advance to plan and schedule maintenance that will prevent a possible surprise outage.

Eaton has chosen to invest in research and engineering to develop insulation systems that reduce the size of equipment using solid insulation, electrical field control, and extremely compact Eaton vacuum interrupters. The company's dedication to a cleaner environment drives them to more innovative methods for reducing the size of equipment, while increasing the capabilities of the equipment at the same time. Additionally, keeping wind farm installations in mind—which may be required to conform to multiple or varying standards—Eaton offers compact medium voltage electrical equipment worldwide that is designed to conform to both International Electric Code (IEC) and American National Standards Institute (ANSI) standards.

References:

1) www.windpoweringamerica.gov/filter_detail.asp?itemid=1917
2) www.epa.gov/electricpower-sf6/basic.html

Initiative for Change

SF_6 is a synthetic compound consisting of one sulphur atom and six fluorine atoms and does not normally occur in nature. SF_6 is gaseous at room temperature and is heavier than air. Due to the strong bonds between the sulphur and fluorine atoms, SF_6 is inert under normal circumstances. This gas has certain electrical properties that make it suitable as insulation and switching medium in switchgear for power distribution. SF_6 breaks down into toxic substances on incineration, for example when an internal arc occurs in the switchgear. In the event of such an internal arc SF_6 gas and its toxic byproducts are released into the atmosphere. These reactions also occur in normal use whenever an arc is suppressed. The toxic residues will then remain in the housing, as a result of which special precautions are required when dismantling and recycling the system at the end of its service life.

Due to a growing concern about the impact of global warming, several utilities and Eaton are joined in the Green Switching initiative. Green Switching is a platform of users, manufacturers, non-governmental organizations, and other participants who are concerned about the growing use of SF_6 for MV applications. The participants share the idea that the use of SF_6 should be prevented wherever there are alternatives available on the market. The Green Switching platform has published a position paper and several related publications. It also presents scientific and technical articles about SF_6 and its alternatives at www.greenswitching.com.

As a result of this Green Switching initiative there is a growing consciousness in the energy distribution market about the use of SF_6. Utility network companies, industrial users, owners of railway and underground infrastructure, and public private investors in the health-care sector are becoming more aware of the health and safety aspects of SF_6 and its toxic by-products as well as its impact on global warming. This has resulted in a growing concern about the use of SF_6 for MV applications.

< Continued from page 15

are many existing synergies between us and we wholeheartedly share the concept of 'practical consulting' for the benefit of our clients. The industry is changing and it is vital that companies evolve in order to meet the needs of developers, owners, insurers, investors, regulators and financial institutions."

To learn more contact Alex Woodward at alexw@naturalpower.com. Go online to www.naturalpower.com.

ROMAX SUPPORTING TAIWANESE WIND ENERGY INDUSTRY

Technical consultancy Romax Technology is providing vital knowledge and services to Taiwan's growing wind energy industry. Through a series of wind energy seminars and partnerships with leading wind energy organizations in Taiwan, Romax is helping leading players in the wind energy industry to realise Taiwan's wind energy potential.

Taiwan has recently identified a need in the reduction of carbon and in the country's reliance on imported fossil fuels for its energy production. The Bureau of Energy under the Ministry of Economic Affairs has set a target of renewable energy contributing to 10 percent of Taiwan's overall electricity generation by 2010, and wind power is expected to make up to 80 percent of that renewable energy contribution. It is anticipated that, due to this commitment and the country's wind resources and manufacturing capabilities, Taiwan's wind power generation will grow to 3000MW by 2020 and create a strong wind energy industry.

However, supplying this quantity of wind turbines from a relatively young domestic manufacturing position requires a rapid development in expertise and capabilities. The Taiwan Wind Energy Association (TwnWEA) has identified this need and in service to its members invited Romax to present a specialist wind energy seminar.

Covering a range of current technical issues including design theory and practice, bearing selection, lubrication considerations, and gearbox testing and certification, Romax provided the audience with their experience and expertise in the design and manufacture of wind turbine drivetrains. Romax is in an ideal position to be discussing these issues, having helped some of the worlds leading wind energy companies to overcome their technical challenges.

In addition, Romax has announced a new partnership with the leading Taiwanese technical research group ITRI (Industrial Technology Research Institute). Romax will develop a wind turbine gearbox testing platform utilizing their testing team and in-house simulation platform, RomaxWIND. To learn more go to www.romaxtech.com.

SIEMENS WIND POWER CONTINUES GROWTH TREND

Siemens has confirmed its objective to become one of the world's top providers of wind turbines. Siemens entered the wind power market five years ago with its acquisition of Denmark's Bonus Energy. Since then wind power operations at Siemens have undergone rapid development. The workforce has grown sevenfold, while revenue has actually increased tenfold. "This is a success story whose narrative we wish to continue," says Andreas Nauen, CEO of the Wind Power Business Unit. "The overall global wind power market is growing at 12 percent annually. We intend to significantly outpace the market growth to become one of the top three providers by 2012."

Siemens' strategy will be to strengthen its position as a global market leader in offshore wind farms while expanding its international production network in key markets and ensuring technology leadership, for example gearless and floating wind turbines, with innovative products. "Wind power has excellent perspectives," he continues. "The global wind power market will grow from about EUR30 billion annually today to more than EUR200 billion by 2030. We anticipate especially robust growth in the Asia-Pacific region. The market growth in North America and Europe, however, will also be significant."

Offshore wind farms are playing an increasingly important role. The potential for offshore wind power in Europe is estimated at around 70 gigawatts, about half of the power plant capacity currently installed in Germany. At present only 1.5 percent of that is being utilized. In the past fiscal year Siemens secured the largest offshore wind power contract ever granted: to provide Dong Energy with 500 turbines of the 3.6-megawatt class. Some of these turbines will be used in the London Array, which will be the world's largest offshore wind farm when it is complete. To date, Siemens has realized 10 offshore wind farms with a capacity of 850 megawatts. Contracts from Germany include the offshore wind farm Baltic 1. Siemens is also successful in the onshore wind power market. In the past fiscal year, for example, Siemens secured contracts for six wind farms in North America and for Europe's largest onshore wind farm in Scotland. Recent orders have come from Mexico and New Zealand.

Siemens Wind Power has pursued a consistent strategy of further expanding its international

production network in key markets. After establishing a rotor blade production plant in Fort Madison, Iowa, Siemens recently began construction on a new nacelle production facility in Hutchinson, Kansas. And in 2010 a plant outside of Shanghai will commence production of rotor blades and nacelles. Production is also planned in India.

Siemens relies on innovative products to ensure its future success. In early December 2009 Siemens completed the prototype of its newly developed gearless wind turbine, which promises even higher availability than standard wind turbines with about half the number of parts. Siemens is also working with StatoilHydro to promote the innovative Hywind project. Hywind is a floating wind turbine that can be positioned in waters from 120 to 700 meters in depth. This opens up new opportunities for offshore wind power.

Siemens Wind Power currently has a record order backlog of EUR6 billion. Over 8,000 wind turbines are in operation worldwide with a capacity of more than 9,600 megawatts. Together they make an important contribution to protecting our climate by saving over 20 million metric tons of CO2 emissions annually. The Business Unit Wind Power is part of the Renewable Energy Division of Siemens, which also includes photovoltaics and solar thermal power plants. Learn more at www.siemens.com/energy.

REPOWER SIGNS CONTRACT FOR WIND FARM PROJECTS IN CANADA

REpower Systems AG has signed a framework contract with EDF Energies Nouvelles and RES Canada that comprises the delivery of up to 954 megawatts for five projects in the Canadian province of Québec, currently developed by the consortium Saint-Laurent Énergies, a Montreal based wind energy company jointly owned by EEN Canada, Inc., RES Canada, Inc., and Hydroméga Services, Inc. The contract guarantees a minimum purchase capacity of 748 MW.

In May 2008, Saint-Laurent Énergies with REpower as turbine supplier was awarded the contract tendered by Hydro-Québec Distribution for five wind farm projects across Québec, comprising of up to 477 REpower MM82/92 wind turbines to be installed between 2011 and 2015. REpower is also responsible for commissioning the turbines.

At least 60 percent of the total investment will be made in Québec, 30 percent will be for the local manufacturing of components such as rotor blades, towers, and electrical converters. Therefore, REpower has concluded contracts with local component suppliers in the Gaspésie-Îles-de-la-Madeleine region and the Matane regional county municipality. REpower CEO Per Hornung Pedersen says "We are delighted that we can today announce the largest onshore contract in our company's history. The contract confirms our strategic partnership with our customers EDF, EN, and RES. This is a giant leap forward for REpower toward our establishment in Canada, and bolsters our intention of further growth in the whole of North America—Canada and the United States."

Repower's Chief Supply Chain Officer Lars Rytter Kristensen adds that "The signing of this contract shows the trust that our customers and Hydro-Québec place in the reliable technology of our turbines. Thanks to the settlement of local suppliers in the region, we can rapidly expand our supply chain and thus our competence on the North American wind energy market."

REpower Systems AG is one of the leading manufacturers of onshore and offshore wind turbines. This internationally operating mechanical engineering company develops, manufactures, and markets wind turbines with rated outputs ranging from 2 to 6.15 megawatts and rotor diameters ranging from 82 to 126 meters for virtually every location. The company also offers a comprehensive portfolio of service and maintenance packages. The profitable and reliable turbines are designed in the REpower development center in Rendsburg and manufactured in the plants in Husum (Northern Friesland), Trampe (Brandenburg) and Bremerhaven. With over 1,900 employees worldwide, the company listed since March 2002 and headquartered in Hamburg can make use of the experiences acquired from the manufacture and installation of more than 2,000 wind turbines around the world. REpower is represented by distribution partners, subsidiaries, and participations in European markets such as France, Belgium, Great Britain, Italy, Portugal, and Spain as well as on a global level in the United States, Japan, China, Australia, and Canada. For more information go to www.repower.de.

VESTAS SPARE PARTS & REPAIR FOR WIND TURBINE OWNERS

Vestas Spare Parts & Repair currently operates offices worldwide to service the world's largest installed fleet of wind turbines. Since January 2009, Vestas has had a dedicated organization for servicing its customers. A brand-new office center next to the Vestas Headquarters in Randers, Denmark, has been constructed. Furthermore, locations for the leadership team are also being set up in Bristol, UK, together

with sections of engineering, customer service, and platform management. In Q4 2009 a gearbox service center was scheduled to open in Spain, and in Q1 2010, a second one is planned to follow in Colorado.

"We are making these radical changes and large investments so that we can further improve the customer experience," says Phil Jones, president of Vestas Spare Parts & Repair. "These developments mark the continued focus on bringing service to world-class standards."

The entire warehouse and distribution network will service the seven Vestas sales business units, and the objectives are to be consolidated into one global, world-class network in 2010. Today, Vestas Spare Parts & Repair has a staff of 230, with the vast majority located in Randers, Denmark. By the end of 2010 an additional 150 people will have joined. To learn more go to www.vestas.com.

MITSUBISHI TO LOCATE WIND MANUFACTURING PLANT IN ARKANSAS

Mitsubishi Power Systems Americas, Inc., (MPSA), has announced its intention to build a wind turbine manufacturing facility in Fort Smith, Arkansas. MPSA plans to invest approximately $100 million in the project, which could employ as many as 400 people.

"We are very excited to announce the future MPSA Wind Turbine manufacturing site in Fort Smith, Arkansas," says Koji Hasegawa, president and CEO of MPSA, based in Lake Mary, Florida. "After an intensive site selection process conducted during the last 15 months we concluded that Fort Smith offers the most attractive site and community support for building and operating our wind turbine plant. We are very thankful for the excellent support provided to us by Governor Mike Beebe, Senators Blanche Lincoln and Mark Pryor, Congressman John Boozman, Maria Haley and her economic development staff, and the entire Arkansas delegation. Additionally, we are also very impressed with Arkansas's commitment to the renewable energy industry. With the establishment of this wind turbine manufacturing plant, we are also planning to expand our component sourcing in the U.S. so as to shorten our supply chain."

MPSA intends to locate its wind turbine manufacturing plant in a new 200,000 sq. ft. facility at Fort Chaffee, near Fort Smith, occupying 90 acres. "The arrival of Mitsubishi in Arkansas is exciting news for our economy and for our renewable-energy manufacturing sector," Governor Mike Beebe says. "Mitsubishi is a brand recognized and respected worldwide, and the substantial investment they will make in Fort Smith is evidence of Arkansas's momentum in the global economy."

The company plans on beginning construction by early 2011. "Arkansas and Mitsubishi are a winning combination for renewable energy and economic development," U.S. Senator Mark Pryor says. "I know that Mitsubishi will benefit from the area's strong community support, work ethic and ingenuity. This partnership will bring America one step closer to realizing the full potential of wind energy."

MPSA currently has more than 4,500 wind turbines in operation worldwide, and over 3,000 wind turbines in the U.S. "Fort Chaffee has a tremendous amount of potential and I am pleased that Mitsubishi Power Systems Americas, Inc. has recognized what Fort Smith and the region has to offer," says U.S. Representative John Boozman. "We are fortunate to have had cooperation at all levels of government and within the community to make Fort Smith standout and MPSA select it for this investment. We welcome MPSA to the Third District, and I look forward to working with the company in the future."

MPSA was established in 2001 with key operations in Orlando, Florida, Newport Beach, California, Houston, Texas, and Juarez, Mexico. MPSA provides a wide variety of products and services for the electric power generation industry including gas, steam, wind, geothermal and hydroelectric turbines, boilers, selective catalytic reduction systems, and solar energy. The company is a subsidiary of Mitsubishi Heavy Industries, Ltd. (MHI), a diversified Fortune "Global 150" company with more than $30 billion in annual revenues and 40,000 employees worldwide. MHI is an international leader in the design and supply of energy, aerospace, machinery, transportation, and environmental systems and equipment. For more information contact Jonathan Wang at (949) 856-8473 or jwang@mpshq.com. Go online to www.mpshq.com.

WIND SEMINARS BY LINCOLN ELECTRIC

The alternative energy industry continues to focus on wind power as a viable addition to address the ever-expanding global energy demand. With this in mind, Lincoln Electric has recently hosted more than 120 industry professionals interested in learning more about wind tower fabrication for several daylong seminars.

Seminar attendees traveled from across the United States and as far away as Brazil and Portugal to Lincoln's Cleveland, Ohio,

headquarters to learn more about wind tower fabrication. Each seminar featured an industry overview, technology sessions, and live welding demonstrations for companies already fabricating wind towers and those currently considering it.

"Governments in every corner of the globe, including the United States, continue to focus on alternative energy, especially wind," says Patrick Wahlen, global segment business director, power generation. "Many of our customers want to add wind tower fabrication to their portfolio, and this seminar shares insight into the industry, guidance on capitalizing on this market and an overview of Lincoln's product portfolio."

Whalen added that the company has long offered a comprehensive welding solution for wind tower fabrication. "In 2008, there were 38 new wind tower manufacturing facilities constructed globally, and 33 of those facilities used Lincoln products," he says.

Due to its Waveform Control Technology®, Lincoln Electric's Power Wave® AC/DC 1000® SD is the leading power source for wind tower fabrication. When combined with Lincoln's process knowledge, it can increase productivity by 30 percent or more. Lincoln also has a complete offering of consumables designed specifically for wind tower welding applications, including tacking, longitudinal can seam, circumferential can seam, circumferential ring and flange, base flange, entry hatch, and rotor shaft.

Steve Knapple, welding engineer for tower fabricator Katana-Summit, attended the May Lincoln seminar and says that "Lincoln did its homework when it got into this industry. They shared insight into areas of opportunity and demonstrated different levels of solutions, which was very helpful as the attendees represented established wind tower manufacturers as well as startups. I also had the opportunity to meet others who do what we do and share best practices. It was a valuable experience."

For more information e-mail windtower@lincolnelectric.com or visit www.lincolnelectric.com.

SLIP SYSTEMS FOR WIND TURBINE GENERATOR PROTECTION FROM CENTA

In wind power plants, electrical circuit problems are known to cause short-term torque peaks. In this event, slip clutches protect the costly gearbox against overload by slipping at a defined maximum torque in order to temporarily interrupt the drive. The slip process takes place not on the generator shaft surface, but inside the CENTA Torque

Hub, which is mounted on the generator shaft in the coupling's clamping set.

CENTA's latest development in slip systems, "CENTA Torque Set," now positions the slip unit to the middle section of the shaft. By relocating the slip function, manufacturing tolerances at the generator shaft no longer cause variations in the slip torque, resulting in improved accuracy of the slip function. Another advantage of the new design is that the slip system is made to be pre-mounted as a complete unit. The maximum torque is set on a certified test bench according to the manufacturer's requirements and documented in a test report, eliminating the need for on-site adjustments.

The low-maintenance slip system is also designed to allow for multiple slip processes (> 200) without having a major impact on the slip torque setting.

Depending on the size, a torque range of up to 120 kNm is covered. The new slip system can also be provided as a low-cost system component which does not include the coupling unit.

CENTA Corporation's newly expanded Chicago facility includes a large in-house machine shop for domestic production of your wind turbine couplings from a trusted source. For more information contact Bob Lennon at (630) 236-3500 or bobl@centacorp.com. Also visit www.centa.info.

ADINDEX

Kenneth Westrick
Founder/CEO, 3TIER

HOW DID YOU COME TO FOUND 3TIER?

When I was in graduate school studying atmospheric sciences at the University of Washington here in Seattle I was thinking of ways to start a business, and since I'd always been interested in renewable energy I was drawn to the idea of using computers to create highly accurate and accessible weather forecasting models. And since I'd spent a lot of time studying the three geophysical tiers, atmosphere, land, and water, I decided to start a company called 3TIER that would encompass those areas and provide Web-based weather information to developers and operators of renewable energy entities, such as solar and wind farms, among others. We refer to ourselves as an "information to decision" company, because we basically provide the data that allows people to make sound judgments to help ensure the success of their enterprise.

DO YOU ACTUALLY CREATE THIS INFORMATION, OR SIMPLY COMPILE AND ORGANIZE IT?

We create about half of our data by taking information from satellites, ground observations, and other sources and applying algorithms that result in highly accurate forecasts for a year, or 30 years, depending on what our clients require. And the results of our computer models provide valuable information that's available at someone's fingertips, online, because you really can't afford to wait in a market that's evolving as rapidly as renewable energy. And it allows you to make informed decisions, as well. For instance, a wind-farm developer here in the Pacific Northwest might want to locate his site in an area that's windier during low-water periods, because that energy will be more valuable when the local reservoirs are half empty. And if you're in Texas, where a lot of wind is generated at night, you'd want to know that during the early stages so you can factor power storage into your plans.

EXPLAIN HOW YOUR SERVICES BENEFIT A WIND-FARM DEVELOPER AS THE PROJECT PROGRESSES.

We refer to the first stage in this process as prospecting/prioritization, in which that developer can follow the "FirstLook" link on our Web site to get preliminary data on the wind resource at a particular location. This service is free, and we currently have more than 50,000 users around the world who access this information. The second stage is "diligence/design," where you're gathering data in order to determine the design of your site... should it all be wind, or should you mix in some solar or hydro, and will the resources support your financials? And the third stage is operational forecasting, where we can tell an operator how much energy the site will be producing from an hour to a week ahead. And all of that information is important to the developer as well as the operator, who needs to know when winds will be high or low in order to make the best use of the chosen site.

IS THIS PURELY AN ONLINE RELATIONSHIP, OR IS THERE A HANDS-ON COMPONENT?

While our group of master's- and doctorate-level atmospheric scientists spend a significant amount of their time running computer models, they have a very close relationship with our clients as well. The fact is, our forecasts grow more accurate over time, so the quality of the information we gather—whether the on-site anemometers have been placed in the best positions, for instance—impacts the outcome. So we definitely rely on input from our clients, and I think the fact that we're currently providing forecasts for about 40 percent of the total wind energy being produced in the United States right now points to the success of our business model. And since we're "technology agnostic," servicing the wind, solar, and hydro markets, we're not advocating any one area, so you can count on the information we provide to be objective, which isn't always the case with other service providers. We are advocates of one thing, though, and that's developing a truly smart grid, where energy derived from all of these existing and developing sectors can be delivered and distributed in a way that makes sense.

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