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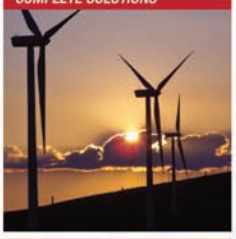

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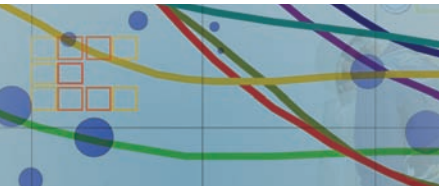

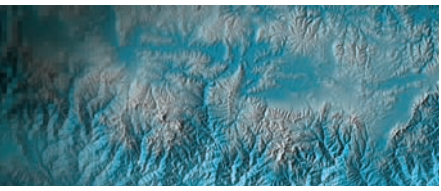


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DEPARTMENTS

VOLUME 2 NO. 13

RESOURCES

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EDLETTER

It's an acronym that anyone in the wind industry is familiar with, especially those involved in site development: NIMBY, or "not in my back yard." And while you can't blame someone for wanting to preserve their natural surroundings, many of those battling against wind-farm development have never witnessed a turbine firsthand. That's why The Eye of the Wind in Vancouver is such an interesting idea. Equipped with a "viewPod" just beneath the nacelle, it provides visitors with the opportunity to get a close look at what a wind turbine is actually about, thereby easing their fears regarding how they sound and appear. I'd like to thank Kellie Lindquist of KONE for "Raising Public Perceptions," her fascinating account of equipping the 223 foot-high tower with an ultra-compact MonoSpace elevator system that quickly whisks visitors up to the viewPod. More such installations are in the planning stages around the world, and providing this kind of personal experience is one of the best ways of alleviating public concerns about wind power.

The remainder of this issue's lineup begins with "Condition Based Turbine Maintenance" by Jianhui Xing of Siemens Ltd., China-Corporate Technology (SLC CT), and Klaus Hoei of Winergy AG, who describe their work in the burgeoning China wind market. James C. Watson and Juan C. Serrano of PPG Industries outline advances being made in "Composite Materials for Wind Blades," and Ken Goering of Intermap Technologies explains how using terrain information accurately predicts wind conditions and helps with project planning in "Harnessing Digital Elevation Data." Alison Wise, who is with the Ecotech Institute, discusses how the rising demand for wind professionals of all types will be addressed in the coming years in "Tracking Renewable Talent," and Michael Hayes provides a case study of how Gleason is helping Brevini Wind USA to meet its ambitious gearbox production goals in "OPTI-mizing Wind Gear Production."

Jose R. Zayas of Sandia National Laboratories describes next-generation wind turbines that are smart, efficient, and reliable in his technology column, and Joseph Mann of Hayward Baker, Inc., explains how rigid inclusions are used in this month's construction column. In his maintenance column, Merritt Brown of Rev1 Power Services presents the first in a two-part series on bolting applications, and Hüseyin Kizilagac of BDP Project Logistics provides insights into successful repowering projects in this month's installment. Dr. Andrew Garrad of consulting giant GL Garrad Hassan was very kind to share the company's history with me—as you know, this is someone who has truly enjoyed a front-row seat to the global development of the wind industry—and Mike Couling, president of Redstone College, describes the creation of its new Wind Energy Technology Program, with its first class having recently commenced.

As you can see, this issue contains a wealth of useful information about new technologies, products, and programs, and I encourage you to contact me at the e-mail address listed below to discuss how we can help spread the news of your own company's accomplishments as well. All best!

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TIMKEN WINS WIND ENERGY CONTRACT

The Timken Company has received a contract worth $26 million to supply wind turbine products and services to China's Xinjiang Goldwind Science & Technology Company, one of the world's top five wind power equipment manufacturers. In 2009 Goldwind received new wind power capacity orders for about 2,722 megawatts, accounting for approximately 19.7 percent of the wind generation added in China last year. Goldwind's contract with Timken will support more than 1,500 megawatts of new wind power capacity, with a broad scope that reflects Timken's long-term commitment to develop wind energy technology. It will contribute meaningfully to the company's expansion in the industry, with Timken providing engineering support, advanced bearings that include the new Timken® UltraWind tapered roller bearings and condition-monitoring systems and services for Goldwind's current 1.5-megawatt and 2.5-megawatt platforms. The companies also will collaborate on future wind-turbine developments.

The agreement reinforces Timken's position as a leader in the sector, providing a customer-focused breadth of bearings and gearbox systems for multi-megawatt wind turbines. The company's product offering also includes a full complement of seals, lubrication, and online condition monitoring and support services for the life of the equipment.

"The collaboration between our companies brings together two leaders developing advanced technologies for efficient, green power generation," says Leong Fang, president of Timken China. "Combining Timken's century of experience with Goldwind's leading innovation in large-scale wind turbines, we are prepared to serve China's needs for renewable energy, and to promote global development as well."

Christopher Coughlin, president of Timken Process Industries, says that "The opportunity to support Goldwind's leadership on these platforms plays to Timken's strength: engineering sustainable systems for large turbines, from a range of proprietary materials to a breadth of power transmission products and services for the extended life of the equipment."

Coughlin notes that the companies have agreed to collaborate further on development programs, including using Timken's advanced engineering design to reduce cycle times for new platforms and incorporating the company's "life cycle" service approach to contribute to sustainable performance and uptime of Goldwind's projects around the world. "We've established wind power manufacturing and service capabilities on three continents, which is important as Goldwind looks to grow globally," he says.

"Goldwind maintains its momentum as a leader in the global wind turbine industry, and we are delighted to partner with

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.

companies like Timken, which earned this opportunity on its performance during our test period last year," according to Wu Gang, chairman and CEO of Goldwind. "We look forward to working with Timken to expand the rapid development of the wind energy industry in China and abroad."

Timken supplies a broad range of wind-power solutions for the global market including engineering design; development and testing support; high quality alloy steels; gearbox components and systems; tapered, cylindrical, and spherical roller bearings; seals and lubrication products; online condition-monitoring; and global field services and technical support. To learn more go to www.timken.com.

VESTAS RECEIVES RECORD-SETTING ORDER IN CALIFORNIA

Vestas has received a 570 MW order for 190 V90-3.0 MW turbines for Terra-Gen's Alta Wind Energy Center near Tehachapi, California. The order has been placed by subsidiaries of Alta Wind Holdings, LLC, a wholly-owned subsidiary of Terra-Gen Power, LLC. Terra-Gen's V90-3.0 MW purchase is Vestas' largest order for a single site. The Alta project also sets several important benchmarks: it will be one of the largest wind power plants in the United States; and together with the bank financing, bond issue, and the sale leaseback financing, the Alta project is the largest financing of a North American wind-energy project, and the first wind-energy leveraged lease to be placed in the debt capital markets.

"The entire Vestas team looks forward to helping Terra-Gen bring this exceptional project to reality," according to Martha Wyrsch, president of Vestas Americas. "When completed it will be the largest wind farm we will have supplied turbines to in our 31-year history as well as the biggest in California. Terra-Gen has selected an excellent turbine and service package. We will work closely with their financiers and customers to make this project successful."

The contract includes delivery and commissioning, as well as a five-year service and maintenance agreement. Delivery is scheduled for late 2010. The first 50 turbines will be commissioned by the end of 2010, and the remaining ones will be online in the first half of 2011.

"We are delighted to have closed this financing and to be working with Vestas on the Alta project," says Jim Pagano, CEO of Terra-Gen. "The project represents an important expansion to the renewable generating base of California and helps us advance our nation's goals of achieving energy independence

in an environmentally responsible manner."

Vestas' manufacturing operations in Colorado will produce wind components for this order. All blades for the Alta project will be produced at Vestas' blades factory in Windsor. And a majority of the towers will be manufactured at Vestas' new tower factory in Pueblo. Terra-Gen Power, LLC, is an affiliate of ArcLight Capital Partners and Global Infrastructure Partners. With more than 830 MW of generating capacity in operation and 720 MW of generating capacity under construction, Terra-Gen is one of the nation's leading renewable energy providers and the only U.S. company that provides electricity on a utility scale from all three major renewable-energy sources: wind, solar, and geothermal power. Terra-Gen has 21 renewable-energy facilities operating in six states, and more than 5,000 MW of renewable energy capacity under development.

Vestas is the world leader in providing high-tech wind power systems. Since 1979 it has supplied more than 40,500 wind turbines in 65 countries. Vestas is investing upwards of $1 billion in the United States to establish its North American manufacturing base, which includes a tower manufacturing facility, a nacelle-assembly factory, and two blade factories. Go online to www.vestas.com.

NEW VERSION OF WINDNAVIGATOR FROM AWS TRUEPOWER

AWS Truepower, LLC, announces a new version of its industry-leading wind prospecting and resource analysis application. windNavigator® 2.2 sets a new industry benchmark for on-demand high resolution wind data and allows wind project developers to expedite all aspects of project design and assessment. windNavigator 2.2 supports wind project siting, resource assessment, and now project design and automated business processes with fast, convenient access to high-quality wind project design data. Users can easily conduct initial project design work including preliminary turbine layouts, initial energy estimates, meteorological tower siting, and more when they combine windNavigator data sets and wind farm design software to capture a true picture of a site or project area's potential for wind development.

AWS Truepower arms professional wind organizations from utility-scale project developers to small wind manufacturers with accurate, science-based intelligence to drive smarter project decisions. Using windNavigator 2.2 developers, manufacturers, dealer networks, wind advocates, academic institutions, and government agencies receive subscription-based access to high-resolution wind data and reports to help them quickly analyze and prioritize business opportunities. The windNavigator application programming interface (API) gives subscribers the ability to "plug in" to windNavigator's wind resource database so they can target, automate, and expedite their marketing and sales processes. windNavigator 2.2 also includes hourly resource information for small wind application load assessments and high-quality modeled data for Measure-Correlate-Predict (MCP) analyses.

"The windNavigator API provides our marketing and sales staff with high-quality data to make efficient and informed decisions about leads and opportunities. Using high-resolution, 200-meter wind data in conjunction with our customer relationship management system (CRM) we can prioritize sales opportunities in minutes," says James Jennings, director of market development for Northern Power Systems.

In the case of multi-turbine wind projects, today's increased focus on reducing development cost and timeline has caused project developers with in-house analysts to seek ways to design and analyze project potential much earlier on in the development process. windNavigator is the first Web-based application that enables wind project developers to purchase 200-meter resolution wind resource grid (WRG) data. With windNavigator 2.2 wind developers can purchase high-quality data sets online, import them directly into their preferred wind farm design software, and go through multiple iterations on a project layout to better understand energy potential on their own schedule with no wait and no extra cost for iterations. For more information go to www.windnavigator.com or www.awstruepower.com.

FINAL PHASE OF BIGLOW CANYON WIND FARM ONLINE

Portland General Electric Company announces the first turbines assembled for Phase 3 of its Biglow Canyon Wind Farm have begun generating electricity and supplying power to the Pacific Northwest's electricity grid. Twenty-four turbines are currently generating power, with all 76 turbines in Phase 3 expected to be completed by the end of the third quarter of 2010. "Bringing the first turbines of the final phase of Biglow Canyon Wind Farm online represents a big step in developing more renewable energy resources for our customers and for the growing wind energy development in the region," says Jim Piro, PGE president and CEO. "We expect to have the entire 450-megawatt wind farm online on time and on budget."

The $1 billion Biglow Canyon

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Wind Farm is PGE's first fully owned wind power facility. Phase 1 of the project began producing power in December 2007 with 76 turbines and Phase 2 in August 2009 with 65 turbines, with a combined generating capacity of 275 megawatts. The addition of the final phase will bring the total installed capacity to 450 megawatts. Given the variability of wind power the plant is expected to produce an average of around 150 megawatts, enough to power the homes of about 125,000 average PGE residential customers.

Trucks carrying wind-turbine parts for the final phase began arriving at Biglow Canyon in April 2010, with about 10 truckloads required to assemble a single wind turbine. Each of the 415-foot-tall turbines, from base to tip of blade, has a generating capacity of 2.3 megawatts. Phase 3 is providing jobs for about 150 employees and contractors during construction.

The Biglow Canyon Wind Farm is located near Wasco in Sherman County, Oregon. It is PGE's largest renewable energy project. When complete it is also expected to be one of the largest wind power facilities in the Pacific Northwest. In addition to providing carbon-free and emissions-free generation of electric power the wind farm is creating jobs, providing income for local businesses, generating tax revenues for local government, and providing easement payments to landowners. The Biglow Canyon project was developed by Orion Energy LLC. It is being built by PGE, which also owns and operates it. Headquartered in Portland, PGE is a fully integrated electric utility that serves approximately 817,000 residential, commercial, and industrial customers in Oregon. Visit online at www.portlandgeneral.com.

WINDPOWER INNOVATIONS LAUNCHES ENERGETIC DRIVES

WindPower Innovations, Inc., announces that its wholly owned subsidiary Energetic Drives, LLC, has been unveiled as its "innovation division." According to John E. Myers, president of WindPower Innovations, "We welcome president and CEO of Energetic Drives, Ian K. Griffiths, to our management team. With background spanning multiple disciplines, Mr. Griffiths and his team of engineers and Ph.D.s complete the foundation for positioning us as a leading wind power infrastructure and smart grid solutions company, able to cater to every aspect of the wind power industry."

Energetic Drives' Grid Tie Inverter software, the subsidiary's flagship technology, utilizes proprietary algorithms that dramatically increase the range in which sustainable energy sources can deliver a useable 60 Hz AC to the power grid. "We estimate an increase in efficiency of up to 25 percent," says Griffiths. "For example, a traditional wind turbine has to be turning at a sustained rate, generating 1,200 to 1,800 RPMs, depending on the number of poles per generator, in order to produce useable electricity. Outside of that range, the power is referred to as 'dirty' as it is inconsistent and unusable. Our technology allows the wind turbine to be utilized at a constant 120 percent of the generator rating with our cooling system employed. This proprietary innovation allows 'clean' power to be produced over a much wider range of wind speeds throughout, from 30 to 120 percent of the generator's rating. The technology also provides for a consistent flow of clean, synchronized, unity power energy to the grid, compatible with IEEE 519 and 1547 certifications. Not only does it result in greater profitability for the operator, it is a dynamic tool for smart grid compatibility."

WindPower Innovations—along with its subsidiaries Energetic Drives and XH Industries—is on course to become a leading energy innovation company, featuring new and more efficient proprietary gearbox designs, grid tie components and electronics, and improvements of existing equipment to higher than industry standards at lower than industry rates. For more information go to www.windpowerinnovationsinc.com.

NAG EXPANDS ALGORITHM LIBRARY FOR DESIGNERS

The largest commercially available collection of numerical algorithms for

C and C++, the NAG C Library—widely used for alternative energy research application development—has now been expanded by the Numerical Algorithms Group (NAG) with the addition of over 150 functions for a total of well over 1,300 user-callable functions. The release includes two new chapters on wavelet transforms and global optimization, and a new sub-chapter has also been introduced on option pricing. Enhancements have been made in the areas of statistics, optimization, linear algebra, ordinary differential equations, regression, random numbers, sorting, and special functions.

"We are looking forward to this release because we have found that the NAG Library is very reliable and is easy to work with, through its extensive documentation and very knowledgeable support team," says Bo Yuan, chief technology officer of Ibbotson Associates, a registered investment advisor and wholly owned subsidiary of Morningstar, Inc., a leading provider of independent investment research. "NAG offers us powerful optimization techniques and broad environment support. NAG also enables the use of both serial and parallel processor based numerical computation."

With origins at several UK universities, NAG is a not-for-profit numerical software development organization that collaborates with world-leading researchers and practitioners in academia and industry. NAG serves its customers from offices in Oxford, Manchester, Chicago, Tokyo, and Taipei; through field sales staff in France and Germany; and via a global network of distributors. The mathematical and statistical functions of the NAG Library are widely regarded as the most rigorously tested and extensively documented numerical programming components available. Visit the organization's Web site at www.nag.com.

ICF STUDY SEES SIGNIFICANT SHIFT IN ENERGY SOURCES

ICF International's newly released second-quarter Integrated Energy Outlook projects a significant shift to renewable, gas, and nuclear sources of energy should new carbon legislation be passed by the U.S. Congress. Energy experts at ICF International, a leading provider of consulting services and technology solutions to government and commercial clients, foresee the retirement of a substantial number of coal-fired electric generation facilities because Hazardous Air Pollution (HAPS) regulations will require large capital outlays for pollution control equipment.

"Uncertainty has become a constant in the energy industry

in the wake of unstable commodity prices, price volatility, and looming environmental regulations," says John Blaney, senior vice president. "The ICF Integrated Energy Outlook provides thorough analysis by energy experts and gives guidance that makes sense of the complicated energy landscape."

The latest version of ICF's quarterly Integrated Energy Outlook seeks to answer the key industry questions of whether energy market prices will continue to recover or slip back to 2009 levels, and how energy prices and new regulations will influence power markets. Using a suite of proprietary analytical tools, ICF has worked to integrate the areas of wholesale power, transmission, fuel, and emissions markets in order to offer the most complete picture of the energy industry. By incorporating expertise from all areas of the industry the Outlook is able to provide big picture guidance, as well as market-specific projections and forecasts. For more information visit www.icfi.com/energyoutlook.

3TIER Q2 PERFORMANCE MAP SHOWS WIND INCREASES ACROSS U.S.

3TIER, the global leader in renewable energy information services, has released its Quarterly Wind Performance Map showing that the intensity of the wind in the second quarter of 2010 has increased significantly in large portions of the United States. This upswing in wind is in marked contrast to the depressed average wind speeds experienced during the last quarter of 2009 and extending into the first quarter of 2010. These abnormally low wind speed conditions were the result of a long-lasting El Niño effect coupled with a strong, negative North Atlantic Oscillation (NAO) event.

"Swings in wind performance are common and part of the inherent nature of the resource," says Scott Eichelberger, Ph.D., 3TIER director of advanced applications. "It's clear that both the El Niño and NAO phenomena have weakened significantly and continue to wane. As a result above-average wind speeds have been experienced in the majority of the western U.S., extending from Washington State to Texas. Wind speeds in other areas of the U.S. were much closer to their long-term average."

3TIER generated the Q2 Wind Performance Map using observational data and numerical weather prediction modeling. The map illustrates departures from the long-term mean that range from -10 percent to +10 percent, showing a pattern that is indicative of the climate state during the quarter. It provides an indication of how wind farms should have performed relative to their long-term production average based on their location. As a result of the weakening El Niño and NAO effects, the second quarter saw significant storm activity off the Pacific Coast, which helped drive the overall increase in wind performance in the western U.S. Texas, the country's largest producer of wind energy, rebounded particularly well from the first quarter. Wind speeds over Texas were elevated enough to make up for the first quarter lull and push the state to above average for the year.

"Texas is a good example for how quickly wind resource strength can change," Eichelberger says. "Our data showed below average values during January and February of 2010, the height of the recent El Niño, with a rapid shift to above average values during March and April as it weakened. While our clients are observing these variations at individual wind farms, our global wind resource data allows us to understand these patterns over broad geographic regions. The good news is that wind is predictable. Our computer modeling technologies are able to both quantify and anticipate these shifts, and in the short term, even predict the impacts on wind speed with a high degree of accuracy."

As the wind industry continues to mature and the financial markets remain constrained, 3TIER believes project siting will demand a higher level of rigor when performing due diligence and accounting for long-term historical wind performance. To learn more go online to www.3tier.com.

GE AND SYNAPSENSE EXPAND RELATIONSHIP

SynapSense Corporation, whose technology improves energy efficiency and cuts power and cooling costs in data centers, is deepening its relationship with GE by securing an investment and commercial partnership as part of a focus on digital energy services, the Smart Grid, and ecomagination. GE Energy Financial Services is joining SynapSense's investors Emerald Technology Ventures, Sequoia Capital, Robert Bosch Venture Capital, American River Ventures, Nth Power, and DFJ Frontier in a combined $5 million investment for the development and market expansion of SynapSense's data center monitoring, adaptive control, and energy management technology. Additional financial details of the investment were not disclosed.

"Deepening our relationship with GE through this investment and commercial collaboration will play a major role in helping SynapSense deliver digital energy services that extend wireless control and resource management to the entire IT facility infrastructure," says Peter Van Deventer, CEO of SynapSense.

GE, which has used SynapSense technology in many of its data centers including GE Corporate and NBC Universal since 2008, will now collaborate with SynapSense on digital energy through a commercial partnership with GE Intelligent Platforms, a high-performance technology business that provides software, hardware, services, and expertise in automation and embedded computing. The partnership will combine SynapSense's technology with GE Intelligent Platform's Proficy software and control platform. This combined offering will enable data center operators to optimize energy use by continuously aligning cooling capacity with changes in IT load, saving up to 35 percent of cooling costs while ensuring security, redundancy and resiliency. GE's Proficy software provides real-time insight on data center and other operational performance metrics to give customers information to make better business decisions.

"SynapSense is a strong addition to GE's digital energy, Smart Grid, and ecomagination-related investments, offering multiple commercial and development collaboration opportunities in a data center equipment market estimated at $40 billion a year, with annual electricity consumption costing $7 billion," says Kevin Skillern, head of venture capital investing at GE Energy Financial Services.

Ecomagination is GE's commitment to imagine and build innovative solutions to environmental challenges while driving economic growth. It is designed to help meet customers' demand for more energy-efficient products and drive GE's reliable growth. GE Energy Financial Services has been an active investor in emerging, market-leading ecomagination-, Smart Grid- and digital energy services-related technology companies. SynapSense's data center monitoring and energy management solutions have been deployed in data centers operated by Fortune 500 companies from Wall Street to Silicon Valley. For more information visit www.SynapSense.com. To learn more about GE Financial Services go to www.geenergyfinancialservices.com.

OFFSHORE INDUCTIVE INVERTER COMPONENTS FROM SMP

SMP's chokes for inverters in wind turbines are now also approved for use in offshore installations. These inductive components feature low losses, very low stray fields, and a highly compact design. The chokes' cores consist of powder composites, which SMP has specifically engineered for this application.

The direct current from the wind turbines must be converted into a sinusoidal waveform with the values required by the

grid. The converter's filters, which consist of capacitors and filter chokes, ensure that the current being fed into the grid exhibits a near sinusoidal waveform. To maximize the inverter's efficiency, its components must exhibit low losses. The materials that SMP developed especially for use in its energy-efficient, high-performance chokes have low magnetostriction and exceptionally low eddy current and hysteresis losses. Their encapsulated design ensures that the power converters emit only low-intensity stray fields, so that they do not affect other components. The chokes have a space-saving compact design, are maintenance-free, and have a long lifespan—a significant contribution to cutting the maintenance costs for offshore wind turbines.

Offshore wind turbines are prone to corrosion. To protect them from the corrosive action of the seawater, special salt-resistant materials, additional corrosion protection, and a complete encapsulation of certain subassemblies are necessary. SMP's inductive components for wind turbine inverters are now certified IP66 and approved for use in offshore installations. Because of their high protection class of IP66, these chokes can be fitted outside the inverters, which means that the heat generated by the choke is not discharged inside the inverter. This results in a lower internal inverter temperature, which removes the need for cooling fans, saving both energy and installation space. Placing the choke outside the inverter has the further advantage of reducing the inverter's overall dimensions, which further cuts space and energy demand. To simplify mounting outside the inverters, SMP provides the chokes with special mounting fixtures. The choke and the mounting plate are fitted on the device's outside and the connecting cables pass through a sealed opening.

SMP's product range includes low-loss inductive custom components based on in-house-developed powder composites, such as filter, commutating, step-up converter, power recovery and single-conductor chokes. Many of its products are used in the railway industry. The market for inverters for photovoltaic systems that feed solar energy into the electricity grid and for converters for wind turbines is also experiencing strong growth. In the United States contact Keith Westendorf, Westendorf Associates, Inc., at (414) 380-9730, kwestendorf@westendorfassoc.com, or www.westendorfassoc.com. Also go to www.smp.de.

CH2M HILL TO MANAGE TRES AMIGAS SUPERSTATION CONSTRUCTION

Tres Amigas, LLC, a merchant transmission company, and CH2M HILL—a global full-service consulting, design, construction, and operations firm—announce that CH2M HILL has received a contract to provide program management services for building the Tres Amigas SuperStation in Clovis, New Mexico. Once completed it will tie together America's three power grids for the first time. Construction is projected to commence in

Continued on page 58 >

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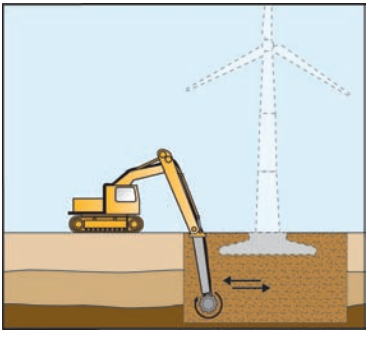
Joseph Mann
Hayward Baker, Inc.

Mass stabilization is a soil mixing technology for treating potential wind tower sites with weak organic soils and high groundwater conditions.

AT PLANNED WIND TOWER SITES a geotechnical investigation and/or environmental evaluation should first be performed to characterize the underlying soils. The results of these investigations may determine if a project can proceed, and they will influence many decisions throughout the design and developmental phase. During site exploration identification of a near-surface organic layer, excessively soft soils, or environmental contamination can have a major impact on the suitability of a site for wind tower construction. These "red flags" have the potential to halt a project or require deep foundations or innovative ground improvement technologies such as mass stabilization.



Mass stabilization is a soil mixing technology developed to treat near-surface weak soil (soil mixing technology was detailed in the May 2010 installment of this column, which is available at www.windsystemsmag.com). Mass stabilization was developed in Sweden, Finland, and Japan in the 1960s, and it has been used abroad extensively for road and railway projects over peaty (organic) soils and for land reclamation and environmental applications. In the United States mass stabilization has been used for roadway, building, and tank support, as well as to stabilize sludge ponds at petrochemical plants.

The goals of most ground improvement programs at wind tower sites are to improve bearing capacity, limit settlement, and/or mitigate potential seismic hazards of the planned wind tower, where applicable. Mass stabilization can address these issues in shallow soils less than 20 feet below ground surface. The presence of contamination may require additional environmental criteria. Having been utilized extensively as an environmental remediation technique, mass stabilization can improve strength characteristics of a soil while also reducing permeability/leachate potential and fixating contamination in place.

The product of mass stabilization is a stiffened mat of soil-cement, often referred to as "soilcrete." This mat of soilcrete is composed of individually mixed "cells" and is constructed beneath a proposed structure, such that loads are transferred primarily in axial compression through the mixed soils to a deeper, more-competent soil stratum.

Construction is executed using a purpose-built power mixing tool. This tool resembles a large drum with protruding blades that spins on a horizontal axis mounted to the end of a sturdy steel shaft. Pinned to a hydraulic excavator, the power mixing tool rotates the drum while penetrating the ground to mix a soil mass. A binder delivery tube and outlet introduces a binder at the drum of the power mixing tool. Pneumatic or hydraulic delivery methods transfer the binder through the delivery tube and into the soil mass. Binder materials include lime, cement, fly ash, slag, and admixtures. Soil type, groundwater location, and the presence of contamination will determine the types and dosage required of the binder options. Accordingly, an early step in most mass stabilization projects is the collection of site soil samples followed by laboratory-prepared trial mixes and laboratory tests to determine the effectiveness of the binder materials and the quantities required to meet project goals.

Quality assurance and control (QA/QC) should be implemented for every phase of a successful mass stabilization program. A proper QA/QC program should include pre-production field sampling and laboratory testing, electronic metering and tracking of construction materials, post-production sampling, and load and penetration testing. An onboard data acquisition system is fitted to the mass stabilization rig to monitor binder dosage and mix parameters such as cell identification, working grade, binder dosage rate and pressure, tool RPM, total quantity of binder added during mixing, and mix depth. Because soilcrete performs as strong soil, the final product is most appropriately evaluated from the geotechnical engineer's perspective.

Foundation system options for new construction may be complicated by weak and organic soils or environmental contamination. Mass stabilization is a cost-effective solution for treating potential wind tower sites with these weak organic soils and high groundwater conditions.

Joseph Mann is a project manager with Hayward Baker, Inc., the leading specialty foundation and ground improvement contractor. He can be reached at jamann@haywardbaker.com. Go online to www.haywardbaker.com.

BUILDING BIG THINGS FOR TOMORROW

BEGINS WITH MAKING THE RIGHT CHOICE TODAY

With expected increases of wind power generated electricity, many manufacturers will be faced with new challenges when producing components such as gear boxes, casings and shafts.

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Merritt Brown
Rev1 Power Services, Inc.

If you see to the little things, the big things will take care of themselves. That's certainly true in bolting applications, as this a two-part series makes clear.

IT IS NEVER A PRETTY SIGHT to see a wind turbine collapse. Whether it is material fatigue, defective parts, or severe weather that play a role, the fall is likely to be its final act, sending 200 tons of technology crashing to complete destruction.

The industry landscape is mottled with such catastrophic turbine failures in recent years, with some gathering more visibility than others due to public safety concerns and a need to determine the failure mode. While the jury remains out on a few, others can point to material fatigue or induced stresses beyond design limits that caused bolted joints to fail and turbines to self destruct. It is always important to determine the contributors to these incidents, and to what extent the installation process and ongoing maintenance may play in preventing them.

High-strength bolts are used on nearly all wind turbine major component assemblies including base and tower sections, blades, hubs, and main shafts. Such bolting is complex mechanically engineered hardware using different materials and thread types, assorted lengths, a variety of coatings, various classes of fit, and multiple grades.

For preloaded joints the turbine manufacturer must specify the correct bolt, lubrication, torque or tension value, and assembly method for each bolted component in order to assure the optimum operating life of the bolted connection. Equally important at the construction site is proper storage of turbine components and bolting, torque or tensioning tool calibration, and adherence to the assembly procedure. Premature failure of the connection can happen when any of these critical steps are overlooked.

An international standard, ISO 898, defines the mechanical and physical properties for metric fasteners and provides the basis for ATSM (American Society for Testing and Materials) standards that apply to U.S. manufacturers of high tensile bolting. In Europe two series of product standards—the HR (British/French) and the HV (German) systems—apply, and these bolt markings may be found on most installed wind turbines today that originated from European countries. Regardless of the country of origin, the standards exist to ensure consistent methodology for determining critical aspects of preloaded bolting assemblies.

An obvious application for wind turbine use, preloaded bolts are advantageous if vibration is present, if slip between joining parts must be avoided, and if the applied load through the joint frequently changes from positive to a negative value, as is found in blade bolting.

For a construction site, OEMs specify proper storage requirements for all bolting assemblies. The term "protected storage" is specified with the intent that the condition of the components be maintained as nearly as possible to the as-manufactured condition until they are installed in the turbine.

This means the bolt assemblies should be stored in closed containers to protect them from dirt and corrosion, the closed containers should be stored in a protected shelter and removed only when needed, and any unused components should promptly be returned to the protected storage. Why all this special handling? Because the surface finish of a bolt, particularly with or without corrosion and lubrication, plays a determinant role on the clamping load.

To fully appreciate the relationship between a torque and the tension applied to the bolted joint, keep in mind that torque measures resistance to turning. Torque wrenches do not give a direct measurement of the clamping force of the bolt, and their readings are affected by such things as dirt, surface finish, and lubrication.

Corrosion in the form of friction can translate into higher torque readings, actually creating a condition where the bolt is not properly tightened and causing failures by allowing a joint to come loose. It may also allow the joint to flex and thus fail under fatigue. Conversely, thread lubrication is a crucial OEM specification that reduces torque values, sometimes by as much as 25 percent. With such a broad topic to cover, we'll continue our discussion of bolting applications in the October issue of *Wind Systems* magazine.

Merritt Brown is director of business development with Rev1 Power Services and Rev1 Wind. To learn more call (866) 738-1669 or go online to www.rev1wind.com.

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Jose R. Zayas
Sandia National Laboratories

Next-generation wind turbines will be smarter, more efficient, and more reliable than ever before, continuing the innovative process that is propelling this industry forward.

ACCORDING TO WIKIPEDIA, innovation is a change in the thought process for doing something, or the useful application of new inventions or discoveries. It may refer to an incremental emergent or radical and revolutionary changes in thinking, products, processes, or organizations.

Since the global acceptance of the utility-tied, three-bladed upwind configuration over 30 years ago engineers and scientist across the globe have developed innovative techniques and improvements to increase the efficiency, availability, and reliability of wind turbines. Efficiency improvement options are always attractive given the strong coupling to cost-of-energy (COE) and because of the ease of calculating the return on the investment. Revolutionary examples of innovation over the last 30 years include the use of laminar airfoils, the transition to variable speed and pitch from stall-regulated designs, and many more. These innovations have enabled the wind industry to become globally cost competitive, and to install products that are designed for a 20-year lifespan.

As we look to the future, the large "low-hanging fruit" of efficiency improvement areas for land-based deployment are no longer there, and designers, engineers, and scientist at national labs, universities, and manufacturers are evaluating, designing, and implementing concepts that are focused on refining and improving the technology.

Ongoing research—taking place both domestically and internationally—focused on next-generation concepts has identified the viability and feasibility of active aerodynamic surfaces on wind turbine blades. The primary concept is to design and implement low energy consuming, fast acting, and simple aero surfaces that can modify the localized flow in order to affect the high frequency content in the wind. This capability will provide designers with a new set of actuators that can be managed to fine-tune the performance of machines and will be able to adapt to local atmospheric phenomena that are difficult to resolve with current actuation. Initial results from Sandia National Laboratories' SMART rotor program have shown the ability of these methodologies to significantly reduce system loads and enable designers to increase the rotor size for a given architecture, yielding a net annual energy increase.

In order to fully realize the benefits of active aerodynamics, the localized conditions must be understood. Cost effective sensor technologies that provide the necessary information (load, pressure, etc.) and have the appropriate resolution must be collocated near the actuators to be able to control the surface effectively and efficiently. Although the initial results are quite promising, it is important to keep cost, reliability, and maintainability in mind in order to ensure the implementation and acceptance by the industry.

Innovation such as the SMART program will always be a part of technology development. Although cost competitive, the wind industry must continue to identify improvement areas to increase viability and ensure that wind can compete in athe diverse energy sector of the future.

SMART Objectives

Sandia is creating concepts that will enable the utilization of longer blades that weigh less, are more efficient structurally and aerodynamically, and impart reduced loads to the system. Concepts being developed include and combined:

- More efficient blade structures (thick airfoils, designs that fully integrate structure and aerodynamics, and slenderized blade geometries);
- Adaptive structures for load control (passive and active);
- Materials and manufacturing improvements involving new materials for wind turbine blades such as carbon, carbon-hybrid, S-glass;
- Embedded sensors for condition health monitoring and controls;
- High fidelity computational analysis of advanced aerodynamic concepts.

Source: Thomas D. Ashwill, Sandia, "Materials and Innovations for Large Blade Structures: Research Opportunities in Wind Energy Technology."

Jose R. Zayas is the program manager of Wind & Water Power Technologies at Sandia National Laboratories. Go online to www.sandia.gov/wind.

Hüseyin Kizilagac
BDP Project Logistics

Successful repowering projects can only be achieved by considering the transportation and logistics challenges of removal and replacement of wind power structures.

RENEWABLE ENERGY is certainly living up to its name. To provide greater wind production and lower operational costs, wind farm "repowering" is emerging as a significant factor in an evolving wind power marketplace.

Components at highly productive wind farm sites older than 10 years are candidates for upgrading, especially where small- and mid-sized turbines are currently in place. Investors and developers are looking for increased revenue and lower costs, and they are turning to the next generation of turbines to deliver higher productivity and greater efficiencies while reducing or eliminating problems associated with aging components.

Repowering is seen as the answer. The multi-megawatt wind turbines are more efficient and quieter, and they can increase wind power production by three or four times compared with many of the turbines presently in operation. Repowering also results in large numbers of turbines entering the market. These are often dismantled and sold to provide electricity in emerging markets such as Africa and Eastern Europe.

That's the good news. The old turbines and even towers—perhaps sold to another company—must be transported from the existing location to another location and new replacement turbines brought in to the jobsite. This is logical, but also logistically challenging, because there is now twice the volume of components to transport, and both ways. Few really thought about repowering being an additional volume issue.

A MATTER OF CAPACITY

While two-way transportation of components can provide supply chain challenges, such as increased jobsite traffic, there is yet another transportation and logistics issue with which developers must contend.

In an earlier installment of this column in *Wind Systems* we discussed supply chain constraints due to general equipment unavailability and the squeeze on transport capacity, not only in the United States but worldwide. In addition to new wind farm projects and those delayed for a wide range of reasons, the capacity stakes will increase, thanks to the huge potential of the repowering market.

Considering the widely varying forecasts for new and repowering projects, onshore and offshore, the demand for equipment and transportation resources could be a black hole—nobody knows for sure how many projects requiring transportation there will be.

What is certain is that competition for resources and equipment will become fierce as more and more players enter the market. The repowering segment will demand access to an already challenged supply of transportation equipment. Already, it appears that capacity shortages will be greater than was anticipated earlier this year.

"If you are or will be engaged in the repowering market, you must plan earlier and with more precision than ever before"

If you are or will be engaged in the repowering market, you must plan earlier and with more precision than ever before in order to be prepared. Capacity requirements must be reviewed and decided at the same time as plans are being made for any wind farm project requiring equipment.

Working with an experienced project logistics resource for all your repowering transportation needs can save you a lot of headaches. A reliable resource with global sourcing capabilities and a wide range of transportation partnerships will help ensure you leave nothing to chance.

Whether transport to and from the jobsite, or advance planning to ensure that you get transportation equipment for your wind components, look for a logistics resource that can provide solutions that go beyond the usual wind power project services—a resource you can rely on in a demanding and constantly changing wind power market.

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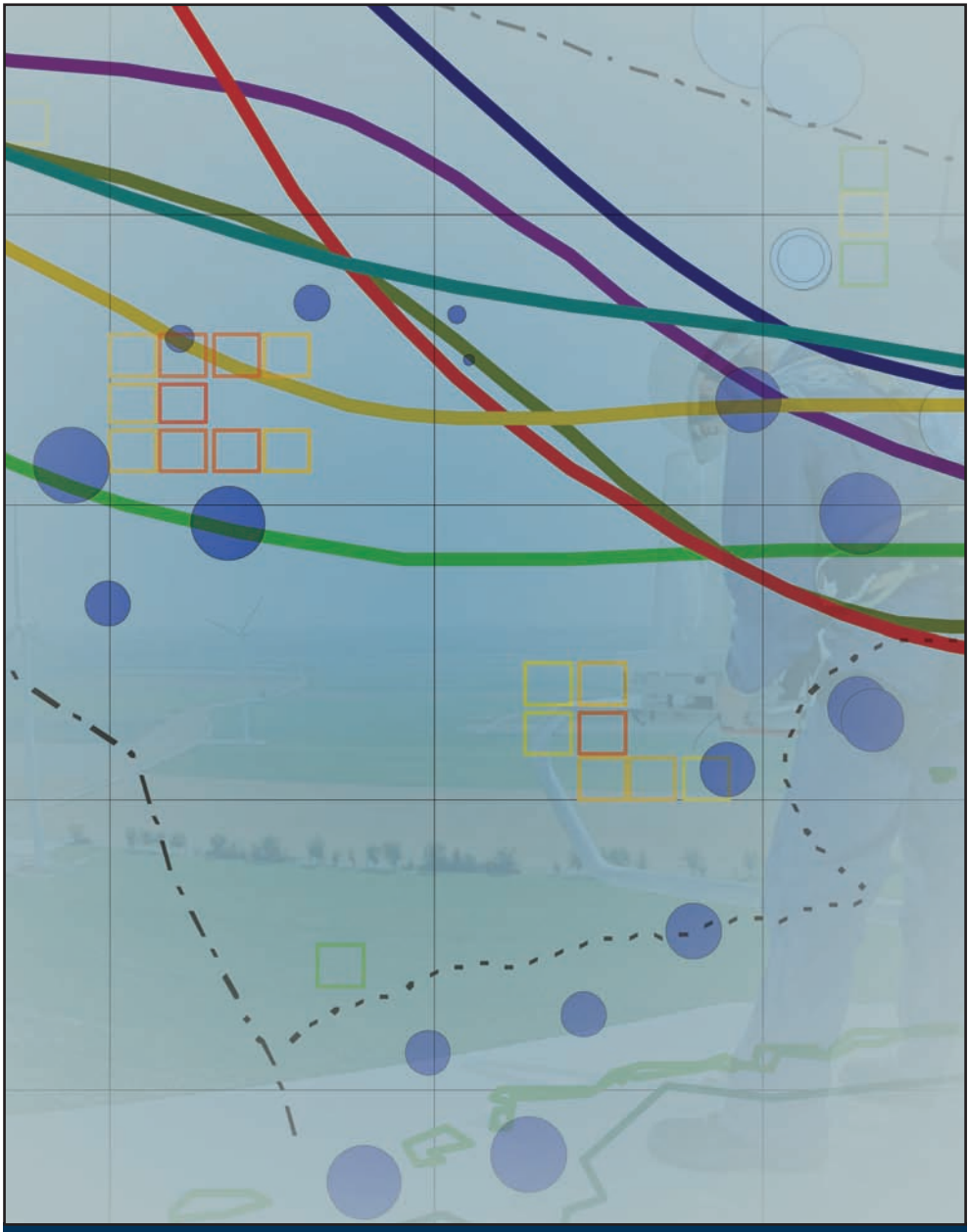
PROFILE

GL GARRAD HASSAN

By Russ Willcutt



With roots in academia and R&D this company offers independent technical and engineering services, products, and training to the wind, wave, tidal, and solar sectors.

THE YEAR WAS 1984, and Drs. Andrew Garrad and Unsal Hassan had been working for the Wind Energy Group—an R&D venture comprised of three partners including British Aerospace, the General Electric Company (GEC), and Taylor Woodrow—for the past five years, since 1979. Convinced of the industry's viability, and that it had matured to the point where it was time to move beyond research and commercialize their efforts, the two wind-industry pioneers decided to start a company of their own. So with no clients yet onboard, they negotiated office space at a university in return for teaching a few classes, marking the beginning of what has become the world's largest wind-energy consulting group. "Maybe we were a bit naïve in retrospect, but we believed in our own abilities and thought the industry had a very bright future," according to Garrad. "Luckily, that has turned out to be the case."

The two men complemented one another both in temperament and training, with the ebullient Garrad skilled in building mathematical models and the more-introspective Hassan tending toward developing measurement systems. They decided to focus on two areas: writing code to calculate turbine performance—which still exists today as the company's well-known GH Bladed integrated design software package—and creating systems to measure and even predict wind farm output. Two events then altered the company's course, beginning with the deregulation of the UK electricity market in 1990, which created a market for wind farms requiring the type of technical assessment and input the company could provide. This also led to the development of the company's GH WindFarmer software package for site assessment and planning. The other was the advent of the first big utility-scale wind farms in the United States a few years later, with the company acting as the bank/owner's engineer due to its position at the forefront of wind-farm consulting. The virtual collapse of the UK wind market not long after also propelled the company in new directions. "This occurred for political reasons that we won't go into here," Garrad says, "but it forced us out of our comfort zone and out into the larger world. That was the real impetus behind the growth of our global footprint."

There were also pitfalls to be avoided along the way, he explains, including the loss of identity some companies experience as they evolve. "In this industry, many companies that started out as consultants were seduced by the perceived opportunities and became wind-farm developers themselves. We decided to stick to our original concept, which I believe helped us a great deal since we had experience, advanced technologies to offer, and we weren't our client's competition."

The company marked another transition in 2009, when it merged with Germanischer Lloyd to become the GL Group's renewable energy consulting division, now known as GL Garrad Hassan. This was a natural development in the company's growth, according to Andrew Garrad. "I've grown up with this business, and it started off being very much a 'smock and sandals' industry where we were all considered to be eccentric dreamers. But that has changed in recent years, where the conventional power industry has entered the picture in a way they weren't five years ago. So I saw that the industry was really becoming mainstream, and that we needed to grow along with it," he says. "We could've managed that growth on our own, but it would have been much more difficult. We were looking for someone who had the funds to allow us to make further investments toward developing new products and to help improve our geographical reach, but also somebody who knew about the business. I have known the GL Group from the very beginning. GL Renewables Certification is the number-one certification body in the wind business, while I hope GL Garrad Hassan is considered to be the number-one wind consulting firm. So putting the two together made a lot of sense. Although the two GL segments are working independently from each other, this will elevate our offerings to this industry by an order of magnitude. We have 750 staff operating in 22 countries, which is a force to be reckoned with."

As for the future, Garrad says that finding ways of integrating wind farms into the grid is a key issue that must be addressed, and also developing new short-term forecasting methods for predicting how the winds will behave on an hourly basis, and up to a day or so in advance. "With the proper technology, science, and investment, wind could easily be supplying 50 percent of the world's electricity in the next decade or two," he says. "I looked forward to the day when we would be sitting at the same table as all of the more-conventional energy sources, and now we are. And in our new guise, we are well equipped to do so."

Send e-mail to info@gl-garradhassan.com, or go to www.gl-garradhassan.com.

OPTI-MIZING WIND GEAR PRODUCTION

Highly productive new Gleason gear cutting and fine finishing technologies are helping Brevini Wind USA to meet its ambitious gearbox production goals.

By Michael Hayes

Michael Hayes is president of Hayes Marketing, which represents the Gleason Corporation. Go online to www.gleason.com. Also visit Brevini Wind at www.breviniwind.com.

THE CORNFIELDS AROUND Yorktown, Indiana—about 40 miles from Indianapolis—are among the most fertile found anywhere in the United States. It's also the perfect environment for cultivating another kind of business, so it's here that Brevini Wind USA has set down deep roots with a $50-million, 100,000 square-foot ultramodern facility featuring North America's only 6.4 MW test bench for the production of main gearboxes for 0.9 to 3.5 MW wind turbines. This, of course, is the size range typically found in most of today's land-based applications in the region. If you think that Brevini Wind is "betting the farm" on the U.S. wind power market, you'd be right. After all, wind turbine deployments in North America are expected to exceed 40,000 units between 2010 and 2015. While Europe dominated the world market for wind turbines five years ago with 70 percent of new capacity, today the U.S. and China account for 62 percent of new capacity, with Europe following at 27 percent.

Beginning in November of this year the new facility will offer many advantages to wind turbine customers seeking to penetrate the booming North American marketplace, according to Managing Director Dr. Jacopo Tozzi. "Most of the major wind turbine manufacturers are based in Europe, so the logistical benefits of sourcing gearboxes 'locally' through Brevini Wind USA will be significant for them going forward," he says. "We are already seeing evi-

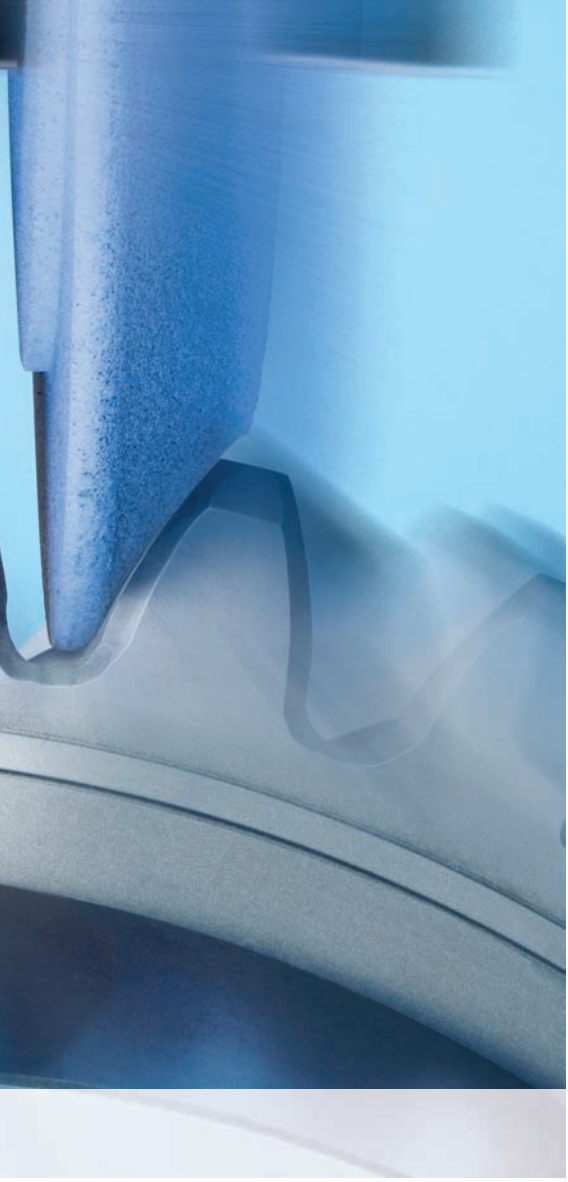


Fig. 1: Maximum OPTI GRIND productivity: An assembly of three dressable wheels rough grinds four tooth flanks simultaneously, as compared to typical use of a single wheel roughing two flanks at once. The center wheel only is then used for finishing, with the desired surface finish and flank modifications dressed into the wheel.

Fig. 2: Ideal for pinion gear production: Another OPTI GRIND variation shown here uses just the two outer wheels with each grinding a flank on separate gear teeth simultaneously. This variation reduces the radial infeed required, as compared to grinding conventionally with a single wheel.

Fig. 3: Maximum OPTI GRIND surface finish quality: A third variation uses two outer wheels with an aggressive grit size to each rough grind a flank on separate gear teeth; then the middle wheel, shown here, with extremely fine grit size, finishes left and right flanks.

dence of this, in fact, with a large order from Finnish wind turbine manufacturer WinWinD for their 3MW wind turbines."

The gears for WinWinD's gearboxes, and Brevini Wind's other customers, will all be produced by Gleason machines employing new technologies that simply didn't exist a year or two ago. Tozzi believes that his company's investment in these new Gleason technologies and processes will help the company to quickly become a major player in the production of a new generation of highly reliable, lightweight, and efficient wind power main gearboxes, giving the company a decided competitive advantage going forward. "Brevini Group, and the Brevini Power Trans-

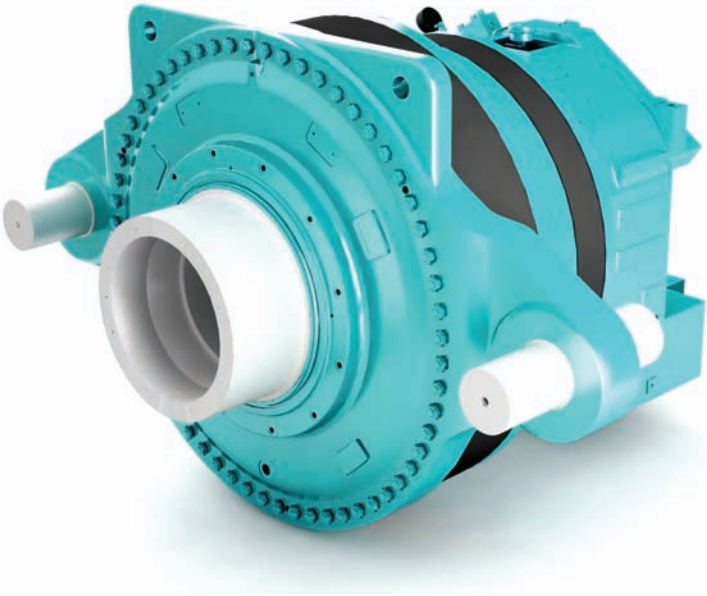


Fig. 4: An example of a Brevini two-stage planetary gearbox, designed for exceptional reliability with a lighter more-compact design providing considerably power.

Fig. 5: Gleason P2400G profile grinder gives Brevini capacity to spare, with capability to reduce by hours the time needed to produce internal and external gears with outside diameters up to 2.4 meters and accuracy requirements of ISO Grade 3 or better.

mission division in particular, is no stranger to wind power, having produced some 60,000 pitch and yaw systems for wind turbines over the years," Tozzi explains. "Our division, Brevini Wind, was established two years ago in order to concentrate on the design, development, testing, and manufacture of main gearboxes for wind turbine applications. This, of course, is one of the most challenging applications for gears, given the high and dynamic loads and the need for extreme reliability. In order to better understand how

our competition was meeting these challenges I had the opportunity to tour many of their plants in Europe, China, and India. Almost without exception, the machines they were using for gear production were made by Gleason."

By November two new Gleason profile grinding machines—models P1600G and P2400G—and two Gleason hobbing machines, models P1600 and P2400, will be up and running at the Brevini Wind USA facility, producing all of the gears found in a series of new generation two-stage planetary gearboxes. These include ring gears with diameters as large as 2.2 meters and accuracy requirements as high as ISO Grade 6 or better, and smaller gears of ISO Grade 5 or better. These classifications are typical of gears for wind turbine applications, although the Gleason profile grinders can actually deliver even ISO Grade 3 or better, if required.

These new planetary gearboxes can produce reduction ratios of up to 37:1 with up to 98 percent efficiency, while at the same time reducing overall size and weight by 25 percent as compared to competitive models. But perhaps most importantly, Brevini Wind will gain an enormous competitive advantage by producing these gears much faster, more accurately, and using fewer machines thanks to a revolutionary new Gleason hard finish grinding process called OPTI-GRIND™. Available only on the latest generation of Gleason profile grinding machines, OPTI-GRIND will enable Brevini Wind to cut precious minutes and even hours out of the time typically needed to profile grind one of its large gears, since productivity gains of up to 40 percent are possible as compared to grinding conventionally. In addition, OPTI-GRIND also can be used to deliver surface finishes better than 0.2 microns; a finish two to three times the level that is generally achievable with profile grinding alone, and so accurate that no additional processes are required after grinding.

According to Gleason Director of Product Management, Grinding Solutions, Dr. Antoine Türich, for the first time OPTI-GRIND solves the dilemma that every gear manufacturer faces: how to achieve, with optimum efficiency, both highly desirable productivity gains and exceptional accuracies. "Wind power gear manufacturers can of course achieve high productivity by using a coarse-grit grinding wheel that will remove a sufficient amount of material when roughing, but these won't deliver the required fine surface finishes," Türich explains. "Conversely, a fine-grit wheel can be used to produce an excellent surface finish, but at the expense of productivity. As a result, grinding wheels are generally used that are a compromise solution, delivering reasonable levels of productivity and accuracy, but well

below optimum levels. But with OPTI-GRIND we can achieve both optimum productivity and surface finishes by simultaneously using multiple dressable grinding wheels for profile grinding rather than just the single 'compromise' grinding wheel typically used."

The new process offers end users like Brevini Wind a number of variations to choose from to meet their specific applications. When optimum productivity is desirable, for example, an assembly of three dressable wheels is used to rough grind four tooth flanks simultaneously, as compared to the typical process of a single wheel roughing only two tooth flanks at once (fig. 1). OPTI-GRIND then is used to finish grind conventionally using just the single center wheel, which has been dressed to produce the desired surface finish and flank modifications.

For planetary gears and pinions, an OPTI-GRIND variation using the two outer wheels alone is available, with each grinding a flank on separate gear teeth simultaneously (fig. 2). This variation reduces the radial infeed required as compared to grinding conventionally with a single wheel. OPTI-GRIND provides a wheel orientation that optimizes the contact angles between the grinding wheel and workpiece flank. This variation offers the largest benefit for pinion type gears because of their substantial profile angle variation from tooth tip to the tooth root.

In applications requiring maximum surface finish quality, a third variation is available. As shown in fig. 3, OPTI-GRIND uses two outer wheels with an aggressive grit size to each rough grind a flank on separate gear teeth, before a middle wheel with extremely fine grit size finishes the left and right flanks.

"It's important to note that OPTI-GRIND uses dressable wheels for fine finishing rather than the non-dressable CBN wheels used in previous multiple-wheel profile grinding techniques. With OPTI-GRIND we give users the flexibility to produce a variety of highly desirable tooth modifications, including grinding of the root without burning," Türich says, noting that on the Gleason profile grinders the dressing unit is actually integral to the grinding head, a unique design that helps to reduce dressing times and improve accuracy and repeatability.

Brevini Wind also hopes to gain yet another edge on its competition by optimizing its "soft" cutting operations as well, with a new Gleason hob design called OPTI-CUT®. Unlike the solid HHS cutters normally used for large gear hobbing, the OPTI-CUT family of roughing and finishing hobs, as well as gear gashers and shaper cutters, are very high quality assem-

Fig. 6: OPTI-CUT hob with replaceable, indexable carbide insert technology significantly reduces total cost per workpiece as compared to conventional solid body cutters.

blies consisting of either five or six cutter body segments and utilizing the latest replaceable, indexable carbide insert technology. By using a cutter with the latest carbide materials, coatings, and cutting geometries, Brevini Wind will be able to run its two new Gleason hobbers at significantly higher feeds and speeds—for both external and internal gears—and even cut dry, helping to make significant reductions in total cost per workpiece. Other benefits include more-consistent tool life and surface finishes, while at the same time eliminating the time and expense needed for resharpening and recoating a conventional solid cutter.

"Launching a company to produce main gearboxes for today's wind turbines is not something that can be done easily or quickly," according to Tozzi. "We have spent a number of years laying the groundwork with the right team of people, and a significant investment in new technologies and processes, with the new Gleason machines being among the most important of these. Now we are poised to help customers take advantage of the enormous potential that exists today and tomorrow in wind power throughout North America."

HARNESSING DIGITAL ELEVATION DATA

Intermap Technologies explains how using terrain information accurately predicts wind conditions and helps to plan project infrastructure.

By Ken Goering

Ken Goering is senior writer at Intermap Technologies. He can be reached at (303) 708-0955, kgoering@intermap.com, or www.intermap.com.

FROM DETERMINING OPTIMUM wind conditions in a large general region to micrositing turbines in more localized areas, the proper location of wind power facilities is imperative. Precise elevation data can be used to develop viewshed analysis, project siting plans, visualization and preconstruction presentations, and other critical aspects of wind power project planning. In short, high-resolution elevation data can improve many physical and environmental suitability aspects of wind power analysis, all while helping to control a project's final cost.

DATA QUALITY AND COST

Elevation data can be gathered from a variety of optical and microwave sensor sources, each with its own set of benefits and drawbacks. For instance, the lowest-cost (or even freely distributed) elevation data has been gathered by satellites. However, most satellite-sourced elevation data has vertical accuracy ranging from 3 to 10 meters. Shuttle Radar Topography Mission (SRTM) elevation data, collected onboard the U.S. space shuttle *Endeavour* in 1990, provides coverage for much of the world at 10- to 15-meter vertical accuracy. At the other end of the precision spectrum is data collected with Light Detection and Ranging (LiDAR) technology, which offers 20-centimeter vertical accuracy, and at a much higher price than other options. Aircraft-mounted interferometric synthetic aperture radar (IFSAR) data, which has an average

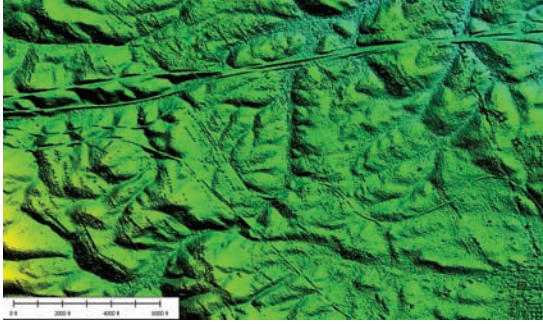


Fig. 1: A digital surface model (DSM) showing a wind farm in California. The DSM provides a geometrically correct base map (area shown is approximately 4.25 miles wide).

vertical accuracy of 1 meter, lies in the middle of that precision and pricing range.

Each digital elevation dataset has a different posting, or the size of the grid on which individual elevation measurements are taken. For instance, a RADARSAT-derived elevation dataset has a 30-meter posting, meaning that elevation values are available every 30 meters in the dataset, with vertical elevation values accurate within 10 meters. Intermap Technologies' IFSAR-derived NEXTMap dataset has a 5-meter posting specification with a predominantly consistent 1-meter or better vertical accuracy.

The range in vertical accuracy and posting specifications of digital elevation data lends itself to the different types of applications in the wind energy market. Reconnaissance mapping, for example, is generally conducted on a 1:50,000 scale and thus requires a less-accurate dataset, whereas micrositing a series of turbines would require significantly more precision since a turbine in a location with prime wind conditions can be almost twice as productive as another located only 30 meters away, the horizontal and vertical accuracy of data used in the micrositing process is critical.

Intermap's NEXTMap USA and NEXTMap Europe datasets provide complete uniform coverage of the contiguous United States and Hawaii, as well as all of Western Europe, respectively. NEXTMap Europe was made commercially available in May 2009, and NEXTMap USA was made fully available in June 2010. The programs mark the first time in history that a private company has remapped, processed, and edited digital elevation data for the United States and Western Europe.

ELEVATION DATA CRUCIAL

Digital elevation data provides information for planning new infrastructure, assists in the prediction of wind condition calculations, and can help project planners make more cost-efficient business decisions about existing infrastructure and accessibility. Wind project planners know that it's important to identify the various factors that can affect a project's cost structure, such as:

- Local policies, including restrictions that govern turbine height, noise levels, and protected environmental areas;
- Product standards and certifications required by local authorities;
- The potential of extreme weather and natural disasters;
- The planned site's infrastructure and accessibility.

High-resolution digital elevation models (DEMs) and aerial images that have been or-

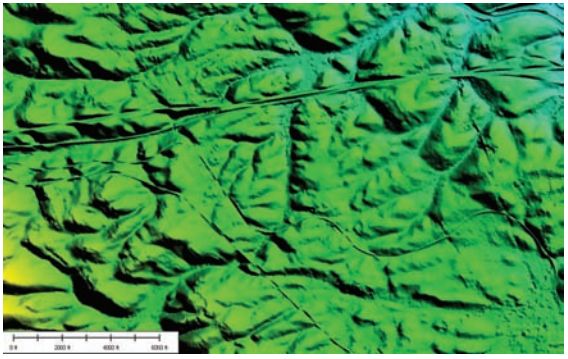


Fig. 2: A digital terrain model (DTM) of the same area, with vegetation and cultural features digitally removed. A DTM reveals terrain characteristics that may be hidden in the DSM.

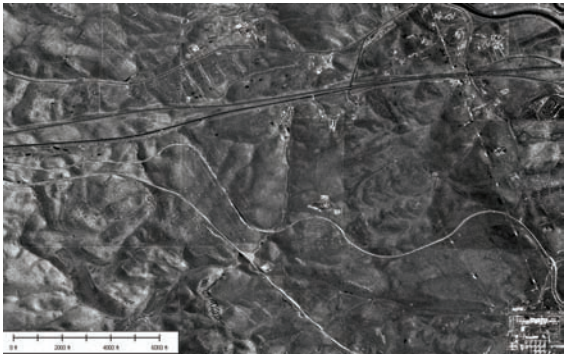


Fig. 3: An orthorectified radar image (ORI) of the wind farm, in which the wind turbines, transmission lines, and power station, among other cultural features, can be clearly seen.

thorectified using those DEMs allow planning to proceed based on the exact geospatial locations of existing infrastructure such as access roads and transmission lines, and therefore more accurately predict the cost of extending transmission lines or building new facilities. Because wind farms are predominantly located in rural open areas or on mountainous terrain, far removed from urban centers where the greatest power demand exists, efficiently locating the best placement of the transmission line corridor is critical to a project's success. Digital elevation and image data provide planners with the ability to take a number of key factors including terrain, land acquisition, and cost into account while optimizing the route of a transmission corridor, all while reducing the costs, time, and risk involved with the project.

For instance, an orthorectified radar image (ORI)—a grayscale image of the earth based on a DEM—accentuates topographic features on the earth's surface far more than what is possible with a standard aerial photograph. An ORI of an existing wind farm allows planners to be aware of the precise location of all current infrastructure including wind turbines, transmission lines, power stations, and highways when considering a possible expansion of the farm.

DEMS PROVIDE PLANNING INFORMATION

Digital elevation models (DEMs)—which include digital surface models (DSMs), digital terrain models (DTMs), and orthorectified radar images—provide a wealth of information about many different aspects of a wind farm development project, and they can help definitively determine whether a proposed site can accommodate wind turbines and supporting infrastructure such as roads and transmission lines. Further, the information can be used to determine the efficiency of turbines in a proposed location compared to those in another location.

Both DSMs and DTMs provide critical information including elevation analysis, slope gradients, and ridgeline locations. DSMs present a wide array of accurate, three-dimensional information about potential site locations, including the crucial viewshed analysis. Adherence to local setback regulations, critical to the local approval of any wind farm planning project, can be achieved with the information conveyed by DSMs.

DTMs, derived from DSMs, are topographic models of the bare earth from which vegetation, buildings, and other cultural features have been digitally removed. DTMs are ideal solutions for planning construction of wind power facilities, from micrositing turbines to placing access roads and transmission lines.

DTMs are also used to develop landslide hazard maps for areas with significant slopes such as ridgelines. For instance, DTMs could be used to classify the terrain in a proposed development area into slope grade categories of less than 20 percent, between 20 and 30 percent, and more than 30 percent, and those categories would then be superimposed with local soil survey maps that provide soil type information such as whether the soil is predominantly silt, clay, or bedrock. The resulting map would provide a planner with information about whether a proposed site meets a local government authority's criteria for landslide hazards.

To help minimize contact between birds and wind turbines, DEMs have been used in studies that combined wind velocity and direction, tower height, and bird behavior such as elevation of their flight, among other factors, with the slope, aspect, elevation, and orientation to wind direction of the terrain.

Still in the planning phase, aerial photography is coupled with digital elevation data to produce three-dimensional visualizations, panoramic views, and line-of-sight viewshed perspectives, allowing planners to see the possible impact of a proposed wind farm development. The perspectives allow planners to realistically see what a proposed wind farm would look like from a particular point on the ground, or to accurately determine how much, if any, of a wind farm could be seen from a particular point.

For instance, a viewshed perspective can show exactly how many turbines would be visible from a farmer's house. Using only an aerial photograph of the house and surrounding terrain, it's difficult to determine the extent to which a series of turbines could be seen from the house. Using digital elevation data together with the aerial photograph, a viewshed perspective will illustrate exactly which, if any, of the turbines can be seen from that house. Viewshed perspectives can be developed with varying factors, such as the radius of the viewshed; a three- or five-mile radius from the farmhouse, for instance.

To help demonstrate the visual effect of a planned wind farm, ORIs provide up to date and accurate information that helps interested parties see the potential impact of a project in relation to existing infrastructure, and to a precision that's unavailable with standard aerial images. Because ORIs are generally derived from DEMs, their horizontal accuracy is dependent on the accuracy of the original digital elevation model. An Intermap ORI derived from a NEXTMap DEM, for instance, has a 1.25-meter pixel resolution—each pixel in the image covers 1.25 meters, or about 49 inches, on the ground—and an average horizontal accuracy of 2 meters. Since they are images rather than digital elevation data, ORIs have no vertical accuracy specification.

TERRAIN ANALYSIS AND WIND MODELING

The software packages that extrapolate wind climate statistics and create wind flow models—information used to predict wind farm production and efficiency, calculate power production, and microsite turbines—use terrain data as one of their primary inputs. In the case of wind modeling the "roughness," or level of terrain detail, of the elevation data used is critical in order to accurately predict wind currents. Forest canopy height data from Intermap's NEXTMap program was recently used in a study conducted by Meteodyn to show the effects of high-level disturbances and strong wind shears in forested areas. DTMs are also used to create contour lines. Together with the land use digital map and meteorological data, contour lines can help determine the potential wind energy that could be obtained at a particular site.

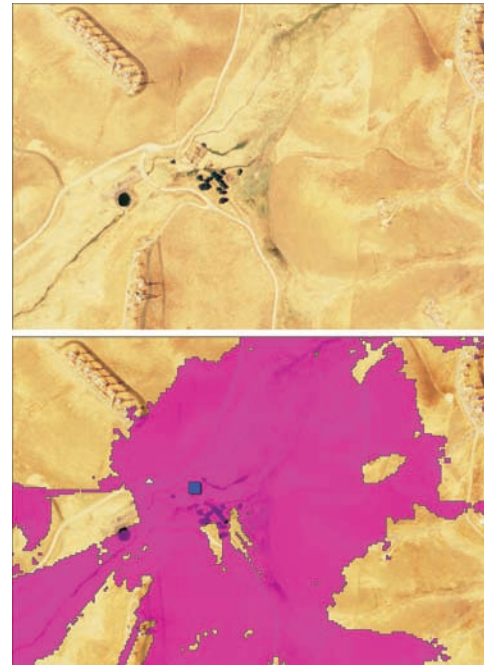


Fig. 4: Aerial photography, such as that from the National Agriculture Imagery Program (NAIP), is combined with digital elevation data to generate line-of-sight viewsheds. The bottom image shows which of the wind turbines are visible (the ones inside the purple polygon) from a farmer's house (blue square in left-center).

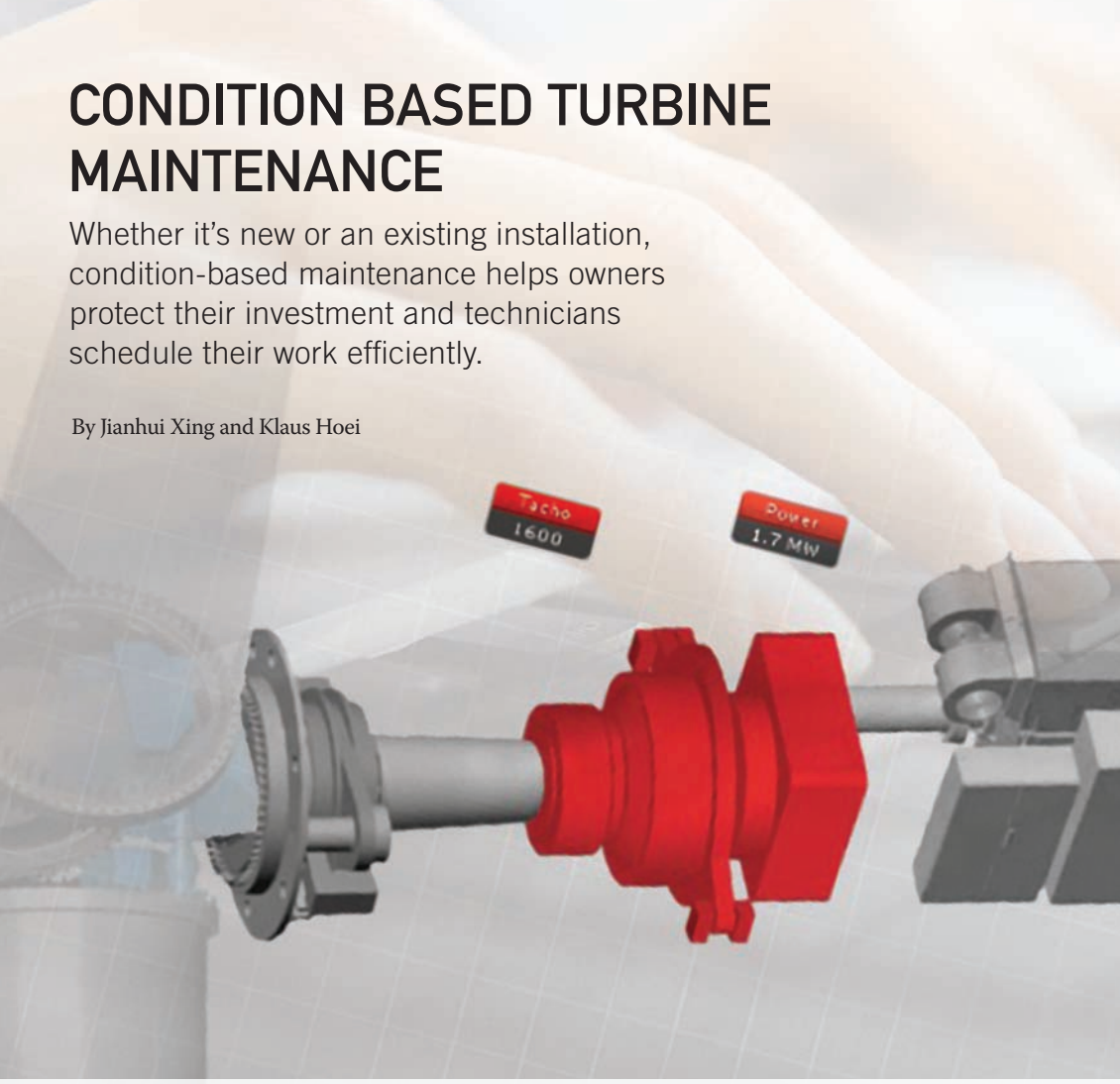
On a regional level, digital elevation data and orthorectified images can help a wind project planner determine the optimum areas in a very large region in order to further refine the search for a project site. By combining various factors such as terrain elevation, slope, land use, access to existing infrastructure and the power grid, federally and locally protected areas, and models of wind power potential provided by software, a planner can localize a search to only those areas that meet each of the optimum conditions. For instance, a planner can restrict site searches to only those areas that are at a certain vertical elevation and within a certain number of miles of the power grid, while excluding those areas that are a certain number of miles within any airports, national parks, urban areas, and many other variables. This approach, generally undertaken with a geographic information system (GIS), saves considerable time and resources while reducing unnecessary risks and costs.

The wind energy applications enabled by digital elevation datasets are wide and varied, and as the industry continues to grow the list of uses for precision elevation datasets will undoubtedly expand as well.

CONDITION BASED TURBINE MAINTENANCE

Whether it's new or an existing installation, condition-based maintenance helps owners protect their investment and technicians schedule their work efficiently.

By Jianhui Xing and Klaus Hoei



Jianhui Xing is lead research scientist at Siemens Ltd., China-Corporate Technology (SLC CT). Klaus Hoei is with Winergy AG. Go online to www.siemens.com or www.winergy-ag.com.

IN RECENT YEARS THE WORLD has witnessed continuous and rapid development of wind power in China. By the end of 2009 more than 20,000 wind turbines had been erected across the country from north to south, and from inland to the coast. As time passes turbines are coming out of warranty, and their maintenance begins coming at the operator's own cost. Therefore, besides the productivity of a wind turbine, wind farm operators are more and more interested in reducing their lifecycle costs; i.e. reducing maintenance costs during the lifetime of wind turbines.

In this context, Condition Based Maintenance (CBM) is recognized as the most practical approach to tackling this market demand. It allows timely maintenance before failure occurs so as to avoid consequential failure escalation and prepare necessary resources, e.g. spare parts, cranes, time slot, etc. At the same time this means increased availability and reduced lifecycle costs. Due to this it is necessary to monitor the conditions of wind turbines and their components in an overall approach based on real-time data on the wind turbine, providing information and automatic diagnosis in advance in cases of potential failure.

With years of experience in condition diagnosis for electromechanical systems Siemens Ltd., China-Corporate Technology—SLC CT, for short—works hand in hand with Winergy to foster the application of condition-based

maintenance in China, to ensure a sustainable future for its ever-growing wind power market. The lessons learned and technologies developed for this particular application will benefit newer, evolving markets around the world, such as that found throughout North America.

RESOLUTION: WINERGY CDS

The new Winergy Condition Diagnostics System (CDS) supports wind farm operators and wind turbine manufacturers with comprehensive health information of their wind turbines. The Winergy CDS goes far beyond a conventional condition monitoring system. It delivers advanced signal processing and automated machinery health diagnostics values on vibration levels, load, and oil properties, therefore permitting more-reliable diagnostics and forecasts about future availability once the operating abnormalities of the wind turbine are detected. You receive recommendations for the necessary corrective action so that your workflow is optimized. Fault messages, diagnostics, localization, forecast, recommended solutions—all of the relevant information is provided in an automated format to the Operations and Maintenance center. All of this happens at once, without any experts being involved, and the information is delivered to the appropriate parties in real time. As a consequence, the all-decisive time advantage is being created in order to secure increased system availability and to minimize the lifecycle costs. It could hardly go any faster.

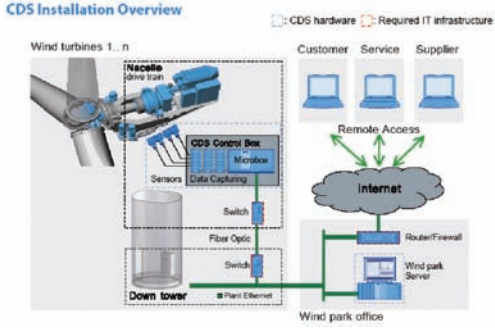


Fig. 1: Condition Diagnostics System installation overview.

Fig. 2: Example of a Winergy CDS located in a central monitoring room.

The following example may demonstrate how an automatic diagnostics system like Winergy CDS can help wind turbine owners keep their turbines in good shape. When a defect is detected on a wind turbine gearbox—e.g. flaking on rolling element bearing or on gears—alarm information will be displayed on the monitoring screen of Winergy CDS which is located, for example, in the central monitoring room of the power generation company (fig. 2). Here the health conditions of all turbines owned by

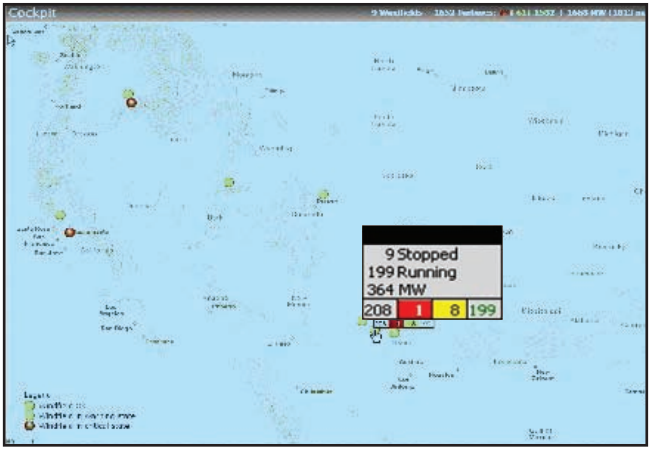


Fig. 3: Example of status overview on a map showing a critical-level defect.

this company are monitored. Operators can identify where the problematic wind turbine stands on a map screen, on which a status overview of all wind turbines is organized as wind farms (fig. 3). The defective wind turbines will be categorized according to different criticality levels. A yellow-colored number indicates how many turbines have detected defects, but can still continuously operate. A red number shows turbines with defects that have reached critical level and need timely maintenance actions. In this example, it reports that a wind turbine has a critical defect and needs to be dealt with immediately (fig. 2).

This information is then automatically sent to the maintenance department, and the maintenance technicians can look at detailed diagnostic results provided by Winergy CDS to arrange their repair work. It shows that the critical-level defect is located in the gearbox with a red color (fig. 4). And when the gearbox icon is clicked, possible defective bearings or gears are displayed in red (fig. 5). When needed, a text message alarm window can point out the defect location, type, criticality level, and recommended actions (fig. 6). Here the defect is diagnosed as a rolling element defect on gearbox's high-speed shaft bearing #542. There are 94 days remaining for continuously normal operation in worst case. Such a clear diagnosis will save plenty of time

on manually analyzing signals and possible defect locations, guiding maintenance technicians in conducting inspection and repairs.

On the other hand, experienced users can still use the state of the art signal analysis tools provided by Winergy CDS, e.g. spectrum, order tracking, trend analysis, etc., to conduct their own diagnosis (fig. 7). The system is based on standard products that are proving themselves in daily operation worldwide. It records, processes, visualizes, and stores signals (analog and binary) and numerical data. Based on the latest industrial PC technology (Microbox PC) and hardware I/O nodes, the modular structure is flexible and grows with the requirements of customers (fig. 8). Moreover, the system can be integrated into existing and new wind turbine systems interference-free and for use with multiple devices. Standardized interfaces ensure reliable, simple connection of the most varied signals sources.

SYNERGY: SERVICE PACKAGE

As the only supplier offering a complete drivetrain of wind turbines to customers, Winergy has the privilege of integrating its CDS system with its after-sales service for its gearboxes and generators. When such a monitoring system issues a warning, wind farm operators must determine what they should do about it. Based on the comprehensive health data from CDS, Winergy provides on-site inspection, professional advice on reaction, repair service, and even long term service agreement for wind farms (fig. 9) so that a real predictive maintenance scenario can be implemented together with wind farms to keep their turbines in good operating order. In the case of wind turbines equipped with non-Winergy drivetrain com-

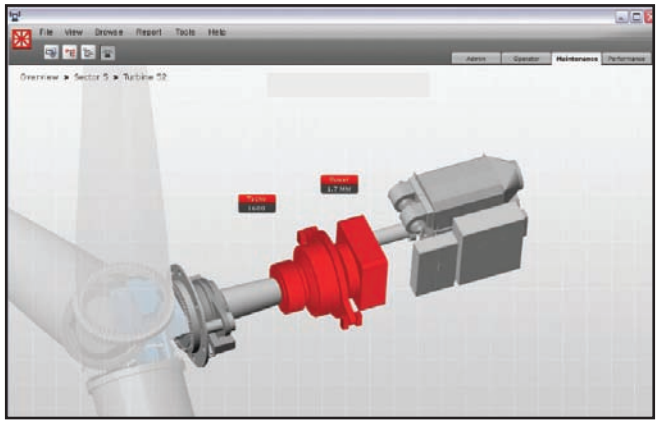


Fig. 4: Example of a critical defect detected on a gearbox.

Fig. 5: Example of possible defective components of a gearbox.

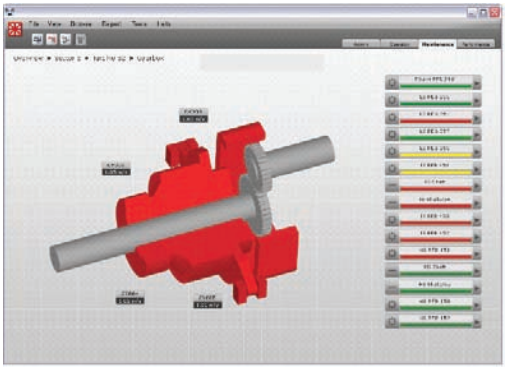


Fig. 6: A text message window provides clear diagnostic information.

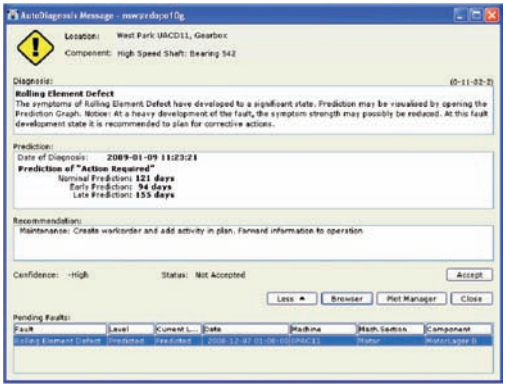
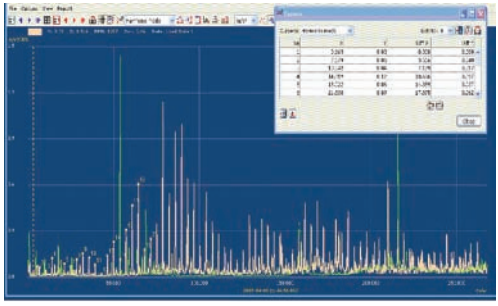


Fig. 7: State of the art signal analysis tools are also available for experienced users.



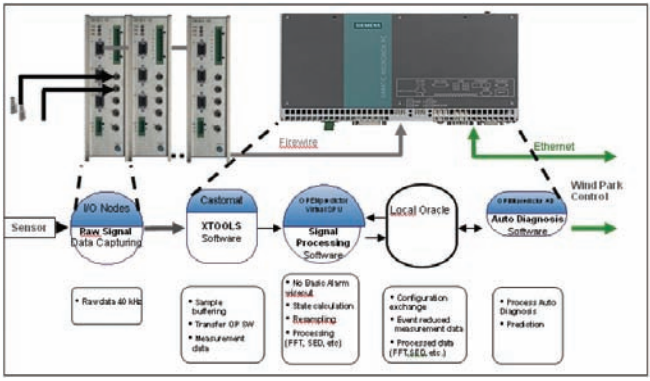


Fig. 8: Overview of the condition diagnostic system.

ponents, Winergy CDS can also be applied without difficulties or reduction of diagnostic functions. Certain service consultancy can be provided to wind farm operators in such instances.

FOSTERING ACCEPTANCE

The sustainable development of the China wind market relies on the profitable operation of wind farms. If not, large-scale application of wind power will become a money-burning game. The condition monitoring and condition-based maintenance for wind turbines seem to be a hopeful solution.

Unlike the European market, however, where insurance companies mandate the application of condition monitoring systems on wind turbines, in the China market wind farms decide whether or not to install such a system on their turbines. Suspicions about the effects of condition monitoring systems always arise when it is introduced to China wind farms, with concerns including: how automatic conclusions are made, and conclusions can be verified; and what should be done when defects are reported by the system—replace the part, or allow the turbine to continue to operate?

This is when SLC CT comes onto the stage. With years of experience on condition diagnosis for electromechanical systems, we help wind farms in China adapt condition-based maintenance with the Winergy CDS system to improve maintenance efficiency and reduce related costs. Capabilities include:

- Conducting onsite inspection and system specification for applying the Winergy CDS at the wind farm;
- Helping integrate Winergy CDS into the wind farm's maintenance workflow;

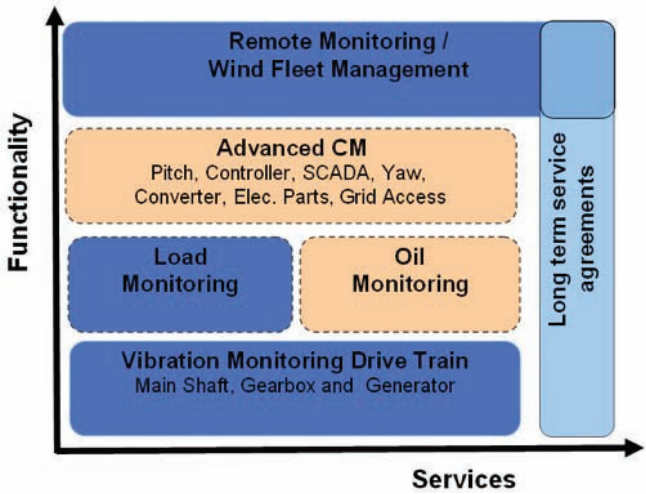


Fig. 9: Winergy service package based on condition diagnostics system.

- Providing consultancy on the automatic diagnosis result by Winergy CDS, thereby increasing user confidence.

Since September of 2009 we have been involved in executing four projects in China, including local wind farms at Gansu, Hebei, Jiangsu, and Fujian provinces, and from the northwestern inland region to the southeastern coast, helping them use Winergy CDS in their daily maintenance work to improve efficiency. Early defects have been reported on generator bearings, and a clear development trend of these defects can be drawn automatically by the system, allowing maintenance technicians to plan their future work in advance.

PERSPECTIVES

No matter where it is located, the world wind industry is beginning to realize that they should not concentrate on new turbine installations alone, but also how to operate existing turbines in a profitable way. Today big wind power owners have begun to think about this maintenance challenge, and a resolution will be required soon. SLC CT will use its experience to continuously help foster the application of condition-based maintenance at wind farms located in China, ensuring the sustainable growth of the wind power industry while contributing to the development of a global green economy.

TRACKING RENEWABLE TALENT

From green power brokers, attorneys, and financial experts to wind turbine technicians, the demand for wind-specific expertise will only grow in the coming years.

By Alison Wise

Alison Wise is director of career services at the Ecotech Institute. Go online to www.ecotechinstitute.com.

ACROSS THE UNITED STATES, the wind energy sector is primed for tremendous growth. More states have set renewable portfolio standards, and with the oil spill disaster in the Gulf of Mexico the federal government is poised to pass meaningful energy legislation that could include a tax on carbon dioxide emissions.

The move to a new energy economy offers a lot of positive outcomes such as lessened dependence on the grid, more sustainable business activities, and a host of new jobs. To meet these opportunities America's workforce, like its energy economy, will need to be retooled to meet the growing demand for skilled labor in wind and other energy-producing sectors.

A January 2009 report delivered by the Council of Economic Advisers found that the clean energy investments of the American Recovery and Reinvestment Act (ARRA) are not only creating jobs today, but for the future. The clean energy provisions of ARRA alone have already saved or created 63,000 jobs and are expected to create more than 700,000 by 2012.

Clean energy jobs, according to the ARRA, are defined as new work for skilled laborers who can install efficient heating and cooling systems and windows, retrofit homes to save electricity, and can build and install solar panels, wind turbines, and other clean energy technologies. These investments are positioning the American workforce to remain competitive and keep our nation at the forefront of a new low-carbon

global economy. At the same time, these initiatives are changing the way that we produce, distribute, and use energy to reduce green house gas emissions and cut our dependence on foreign oil [1].

To better understand where the wind industry is headed and how to meet the increasing job demand, Ecotech Institute spoke to three members of its board of advisors who specialize in the wind energy sector and helped develop the school's curriculum. Those weighing in on the industry's potential and the demand for talent include Abbas Ghassemi, Ph.D., director of the Institute for Energy and the Environment, WERC executive director, and professor of chemical engineering at New Mexico State University; Al Zeitz, director of North American Operations at the DeWind Co.; and Colin Coyne, managing principal of the Coyne Group, LEED 2.0 accredited professional and lecturer of sustainable enterprise at the Kellogg School of Management on "Sustainable Strategy."

SETTING THE STAGE

According to the American Council on Renewable Energy (ACORE), the anticipated increase in wind power energy by 2040 will be significant, as much as a tenfold increase when compared with today's production and consumption. In addition, a study released in February 2010 by Navigant Consulting, Inc., found that the number of renewable energy jobs would more than double by 2025 if the nation adopted a plan to require 25 percent of its electricity from renewable sources. Several states currently have renewable portfolio standards, and the trend is continuing.

"As we approach global peak oil in the next 25 years, optimistically, we must be able to diversify into the many sources available in order to sustain energy production that will allow our economy to grow without intermittent shortages, security vulnerabilities, extreme costs, or environmental degradation," says Ghassemi.

Sourcing United Nations data, an increasing population is a considerable factor when looking at alternative energy demand. "With projected population growth exceeding 9 billion people by 2050," he continues, "global energy consumption worldwide, as well as the estimated domestic demand, increases the need for production, availability, and delivery of energy from all renewable sources [2]."

According to Zeitz there are a number of reasons to anticipate growth in the wind industry, including its benefits as a clean source of electrical power and a good investment. "The development of wind energy for electrical power is growing more popular in the private sector," he says. "Many people would like to see more wind turbines installed to generate electrical power."

"In the past three years, worldwide wind power capacity has more than doubled," Coyne adds. "This is largely due to wind power becoming a cost competitive alternative, especially when one considers that a wind plant is far less expensive to construct than a conventional energy plant. Of course, one can't ignore the general demand for clean power. Certainly this debate will heat up with recent events in the Gulf of Mexico. New clean air standards will also accelerate demand."

DEMAND FOR TALENT

As with growth in any industry, skilled workers are essential to meet the demand. In the case of wind power, people must be able to know

how to build and sustain tools, equipment, and technology. Ultimately, this means jobs—which is obviously positive in a tough economy—but what kind of jobs will they be? Our experts underscored the increasing need for educated, skilled workers across the industry, and what they could be doing.

"There are many different kinds of jobs needed to support the growth of the wind industry," says Zeitz. "However, the greatest number of jobs needed in the wind industry will be technicians. Wind turbine technicians are the backbone of the wind industry, and these technicians will be required to keep the growing fleet of wind turbines maintained."

"From green power brokers to wind turbine technicians, the demand for jobs will be substantial," Coyne says. "At a very pragmatic level, the demand for technicians to serve these new facilities will be great, as will attorneys and paralegals who understand the unique nuances of green power and green power incentives, real estate leases, and project financing."

"To address the ongoing and emerging needs for installers, operators, managers, field crew, and supervisors, we should train individuals in mechanical and electrical fields specific to wind power," according to Ghassemi. "As the ramp-up takes place, there will be significant growth in the manufacturing area for wind blades, structures, gearboxes, and associated hardware, emerging software, and technologies. There will also be a tremendous growth for individuals to maintain and repair gearboxes, energy storage devices, and utility service/integration functions."

CREATING SKILLED WORKERS

Ecotech Institute, which recently opened its doors in Aurora, Colorado, was created to help fill this demand. The first and only school in the United States entirely focused on renewable energy and sustainable design, it offers a path for people interested in entering the green economy with the right education. Ecotech Institute offers seven associate's degrees and a certificate program.

When asked about Ecotech Institute's role in training future workers in the wind industry, the experts were excited about applicable job training, especially for wind technicians. "The wind companies are obviously adept at what they do. However, graduates of Ecotech will bring much needed, on the ground, pragmatic knowledge," Coyne says. "The issue for wind companies is taking what has largely been small-scale or theoretical models and turning them into full-scale operations. This requires well-trained technicians who understand the engineering behind the technology, available in sufficient numbers, and grounded in the mechanical realities of wind power conversion."

Ghassemi believes that Ecotech can help companies find and place "trained individuals to participate in this growth. Ecotech graduates will be able to fill the niche in all of the sectors, including manufacturing in several positions."

"With the number of turbines that are currently installed, and those that are scheduled to be installed," Zeitz says, "the greatest demand is for skilled technicians to commission, troubleshoot, and maintain them."

AN ENTHUSIASTIC FUTURE

A look at the future is exciting for people inside and outside the field. With the potential to bring more sustainable choices to the marketplace and bolster new, diverse workforces, the wind industry offers promise. "We need to continue to be mindful of our energy availability, production, use, and delivery," says Ghassemi. "While we need to have scientists and engineers doing their part in making this happen, job training is vitally important in com-

pleting the cycle and assists in providing the resources required for making renewable energy available."

"So much of the alternative energy discussion has taken place at a global or strategic level," says Coyne. "What has been ignored are the thousands of technical jobs that will turn these ideas into reality. To me, the opportunities of 'green' in 2010 are similar to those that surrounded the space program in 1969. Both were catalysts for a new generation of entrepreneurs."

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COMPOSITE MATERIALS FOR WIND BLADES

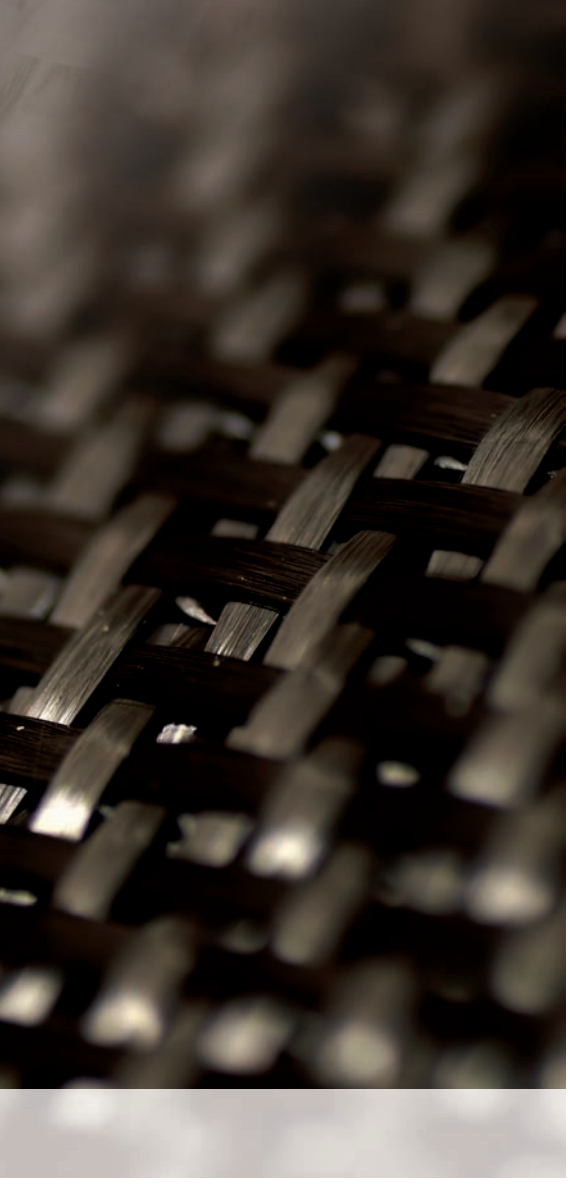
As new materials are being developed, PPG Industries provides insights into the current performance and future directions of those utilized in manufacturing high-tech blades.

By James C. Watson and Juan C. Serrano

James C. Watson is associate director and Juan C. Serrano is an engineering associate at Fiber Glass Science and Technology, PPG Industries, Inc. Visit www.ppg.com.

THE TECHNOLOGY USED in manufacturing wind turbine blades has evolved over the past 20-plus years. Blade making has migrated toward processes that minimize cycle time and reduce both cost and the probability of defects. Early blade building techniques grew out of the boat building industry, using processes that were high in labor and prone to inconsistencies and defects. Vacuum infusion took blade manufacturing technology to a higher level, with improvements in consistency and performance of a blade. Prepreg—or "pre-impregnated"—technology further enhanced blade performance by combining resins and reinforcements in a more rigorously controlled manner before placement in the blade mold. Today the trend is toward Automated Tape Layup (ATL) or Automated Fiber Placement (AFP) to reduce labor and improve quality, whether one uses dry fiber or prepreg tape (fig. 1).

Input materials in blade production have not evolved as rapidly. Resin technology has expanded somewhat to include both polyester and epoxy on a broad scale. Wood or foam cores are still used in many cases. Skins are comprised of multiaxial fabrics with some use of unidirectional materials. The root end section of the blade is comprised of rovings and/or multiaxial fabrics. Spars have been manufactured with fiberglass rovings and a combination of unidirectional and multiaxial fabrics. Throughout the early growth of the industry, basic fiberglass reinforcements have changed very little. The pace of that change, however, is now beginning to accelerate.



Performance of turbine blade composite materials has been documented by many agencies and universities, including Sandia National Laboratories and Montana State University in the U.S. and the Optidat database in the Netherlands. Figure 2 outlines these data sources and provides links to some excellent public Web sites. As part of an ongoing DOE project on Wind Blade Manufacturing Innovation (DE-EE0001373) we have collected and analyzed the performance of turbine blade materials and utilized these databases for input into an electronic database. We have also included PPG internal data and publicly available information from different material suppliers. This data was aggregated and analyzed for performance characteristics based on material type. Detailed analysis of the data shows a basic split in material performance between prepreg and infusion based composites. The highest performance is obtained from unidirectional and biaxial prepreg materials. These materials are utilized on the latest generation of wind turbines. Material properties are more varied in infusion-based composites, particularly as a function of resin selection, reported fiber volume fraction, and material complexity. As fiber orientations shift from unidirectional to biaxial to triaxial, the dominant material characteristic changes as well.

The data contained in these public forums provide a rich body of work for all who take the initiative to explore them. Much credit must go to organizations like Sandia National Labs and their ongoing sponsorship spanning many years of Professor John Mandell and his group at Montana State University. The Wind Center in the Netherlands has also been a leading data provider, as has the Risoe DTU National Laboratory in Denmark. We are able to gain much insight as a result of this work.

The data based on prepreg composites allow us to compare various fiber types as well, including high performance fibers like carbon. The mechanical properties of unidirectional materials when loaded under tension are clearly fiber dominated, which means in the tensile and compressive direction the property of the fiber dominates the composite mechanical property. Specifically, the type of fiber and the amount of fiber determines the performance of the composite material as dictated by the "rule of mixtures" relationship. The advantage of a high performance fiber like carbon is most prevalent in the tensile properties. In the design of a wind blade the advantage of novel fibers like carbon is realized in the tensile direction, and hence is the reason that it is used in parts that undergo high tensile stresses such as a spar cap. In contrast, the compressive properties for carbon fiber reinforced laminates do not differ greatly from cost-effective alternatives like E glass based composites.

The properties of composites based on biaxial fabrics or fiber structures are dominated by the resin when loaded in the primary direction. The use of a high performance fiber does not provide a significant boost in mechanical property values. This is basically a result of moving the fiber orientation away from the load direction. So in using composites fabricated with biaxial fabrics, E glass continues to be a good cost-effective solution for this ply schedule.

The same trends are evident when comparing infusion-based uniaxial and biaxial fiber composites. Once again, higher performance fibers show benefits in uniaxial laminates but not in biaxial laminates. This trend continues in laminates based on triaxial fabrics. In the complex triaxial laminates the improvement in tensile properties is reduced such that there are negligible differences in laminate performance, even when fiber properties are substantially different.

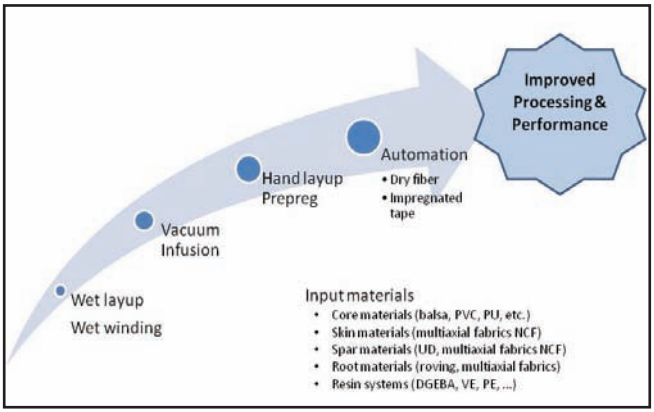


Fig. 1: Evolution of wind turbine blade production.

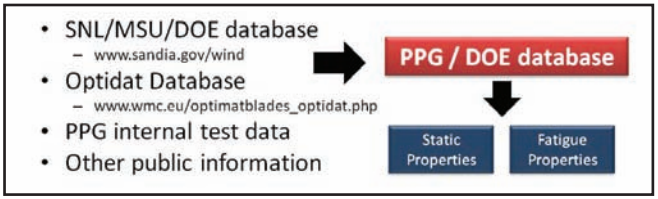


Fig. 2: Performance data sets.

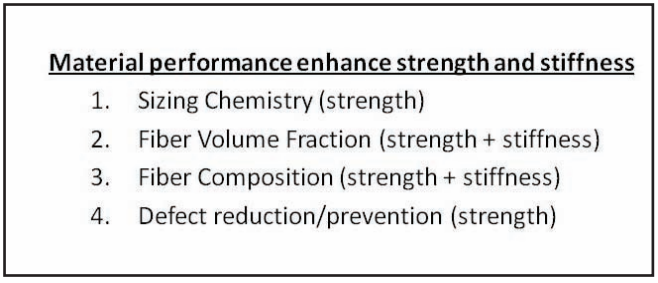


Fig. 3: Driving performance through material enhancements.

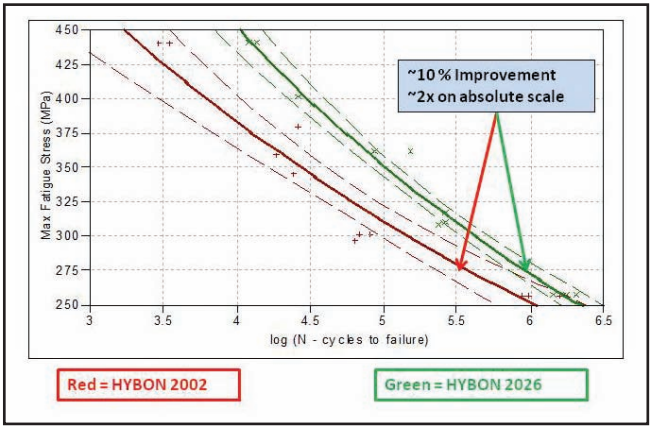


Fig. 4: Sizing chemistry drives fatigue performance.

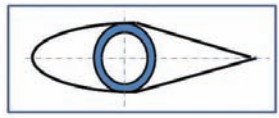
Further reducing the value of high performance fibers in these complex fabric architectures is that other defects can take over. For example, the tensile strength of a fiber is a flaw-dominated property. Damage imparted to the fiber surface in the fabrication of these complex fabrics can reduce the value of the fiber. Since these fabrics are more complex, there is also a higher probability for basic defects (voids) that can compromise the properties. As we move further into more complex fabric architectures, the fiber property difference starts to blur in the performance data given the complexity of the load path, the loss of fiber alignment, and the reduction in effective fiber volume fraction.

Moving from historical data to future developments, the industry is clearly moving toward larger turbines with longer blades. Larger blades produce more energy, and this is a basic target for driving costs down. To grow the size of turbines there are two approaches one can take. Knowing that the deflection of a wind blade is inversely proportional to the moment of inertia of its cross section and the stiffness of the blade material, the goal is to increase moment of inertia or stiffness to reduce deflection. Changing the moment of inertia requires a change of the blade design or blade cross section. This is a design issue best tackled by wind turbine designers and builders, not by material suppliers.

The second option is to change the materials properties to increase flexural stiffness of the composite. From the perspective of the materials supplier, there are a number of ways to accomplish this goal (fig. 3). The first is modification of the sizing chemistry on the surface of the glass fiber. The surface treatment drives wetting, composite tensile strength, and ultimately fatigue life. While these do not affect stiffness directly, they are critical to overall blade performance and durability. Secondly, we can make a stiffer structure by increasing

Fig. 5: Volume fraction scenario (idealized model).

- Circular cross section spar
- Parameters include
  - Outside Diameter (OD),
  - Inside Diameter (ID)
  - Spar Length (L)
  - Elastic Modulus of Fiber (Ef)
  - Fiber Volume Fraction (FVF)



OD = 0.6 m, ID = 0.55 m
L = 60 m
Ef = 79 GPa (Impregnated strand tensile)
FVF = 50%
Modulus translation efficiency = 97%

the volume fraction of the fibers within the composite. Another approach is to change the fiber composition to provide a stiffer fiber. Lastly, providing composites with low probability for defects ensures fewer flaws that can become crack initiation sites in the event of large stresses.

Sizing chemistry effects can be illustrated by comparing two PPG products, HYBON 2002 and HYBON 2026. Both products are used in wind energy composites and are multi-compatible in that they perform well in many organic resin systems. HYBON 2002 is a workhorse product for the wind industry, and its performance is well established. An improved sizing chemistry using the same base fiberglass can be demonstrated by comparing properties with HYBON 2026. This product provides improvements in tensile strength, flexural strength, and interfacial shear strength. The value of these improvements is seen more dramatically in dynamic mechanical properties, specifically fatigue performance (fig. 4). In fatigue measurements the improvement of HYBON 2026 over HYBON 20002 translates to roughly 10 percent on a log scale (from ~5.5 to 6.0), and greater than double the absolute number of cycles to failure (320,000 cycles to 1,000,000 cycles). Benefits from sizing chemistry are especially meaningful when one considers that the chemistry is applied at the fiber level at a thickness on the order of 50-100 nanometers. In addition to fatigue performance, the latest generation sizing developments can provide property improvements that are controlled at the fiber level, which improve strength characteristics and strength retention of the composite. However, sizing chemistry does not have a direct effect on fiber stiffness.

The second option to increasing blade stiffness is to change the fiber volume fraction of the composite. Sizing chemistry can play a role here by providing improved wetting and lower resin demand. In general higher volume fraction laminates are more difficult to fabricate, as the permeability of a larger fiber array will be reduced as fiber volume fraction is increased. This can lead to a higher prob-

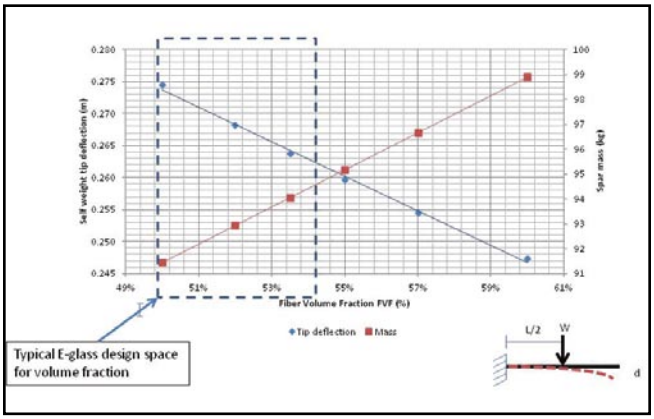


Fig. 6: Volume fraction directly affects beam deflection.

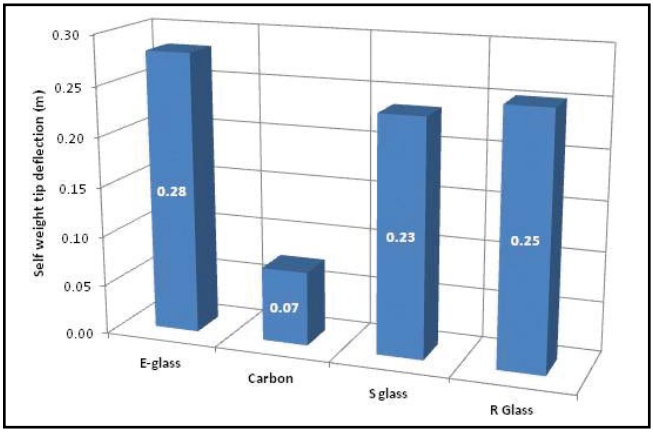


Fig. 7: Edge deflection on spar model; as fiber modulus increases, deflection is reduced but cost per lb of input material increases.

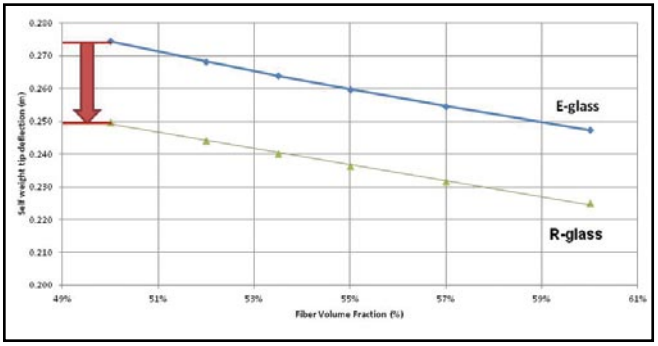


Fig. 8: Composition shift from E to R glass reduces deflection at a given volume fraction.

ability of defects. As the laminate approaches the maximum theoretical fiber volume fraction, the likelihood of dry spots and direct fiber-to-fiber contact leads to a higher incidence of flaw generation. Another negative is that the weight of the composite increases as the fiber volume fraction increases, which is something we want to manage when making larger wind blades.

To further explore the increased fiber volume fraction impact, we will consider the case of a hypothetical spar with a circular cross section (fig. 5). Assume for simplicity that it is produced with all the fibers aligned along the length of the spar. The physical dimensions are held constant, as well as the modulus of the fiber. Using a self weight deformation criterion for the analysis we can see that changing the volume fraction from 50-60 percent does provide tip deflection decrease (fig. 6). At the same time, however, there is a respective increase in the mass of our hypothetical spar. Additionally, more-complex fabric architectures are somewhat limited in their ability to achieve these high volume fraction levels. There is room to increase the fiber volume fraction and increase stiffness without incurring fiber-to-fiber contact. However, there is a weight penalty for increasing the fiber volume fraction on a composite laminate.

The third means of improving stiffness is through changes in the basic glass composition. Every glass manufacturer has a space in which they operate, so we must recognize that there are ranges for the resulting properties. E glasses are well known, and most widely used in the composites industry. However, there are other fiber types that offer higher modulus. These are commonly known as R and S type glasses. Carbon is the ultimate fiber based on very high mechanical properties. As modulus increase it must be recognized that this benefit generally comes at a higher cost.

Using the same equation for tip deflection and changing fiber modulus, we see that tip deflection decreases (fig. 7) as modulus increases. Further comparisons of fiber composition can be made when taking fiber volume fraction into account. In this figure the comparison is made between E and R type glasses. One can obtain the same deflection using 50 percent volume fraction of R glass compared to 59 percent for E glass (fig. 8). Furthermore, note that R glass has a 0.23 m tip deflection at 58 per-

fraction. Volume fraction would need to exceed 60 percent to achieve this deflection with E glass, which is an unlikely scenario. These benefits are driven by fiber modulus, which is on the order of a 10-12 percent change. This can be coupled with an increased fiber volume fraction, which can result in further improvements in laminate stiffness.

The last point of improvement is defect reduction. A number of ongoing current developments are focused in this area. Automation is one means to reduce defects. Current material forms are not adequate for fiber placement and automated tape laying. On the chemistry front, resin specific sizing technology will provide better bonding to the resin and can reduce defects at the micro-scale. There is further value that can be obtained through higher tensile strength, interfacial shear and strength retention properties. This approach can also give greater fatigue performance. Faster processing can also be enhanced through sizing chemistry changes.

In conclusion, the focus has shifted from incremental improvements in performance to performance leaps. Interest in the reduction of defects and in cycle times by the introduction of high-end processes will drive this change. We are working on developing materials that are appropriate for the emerging technologies. Considerable research is ongoing in improving wet-out characteristics of rovings and fabrics and providing higher mechanical property retention over the life of a blade. New technology developments in fiber reinforcements, resin systems, and production concepts will continue to drive wind energy to lower cost of energy levels in the future.

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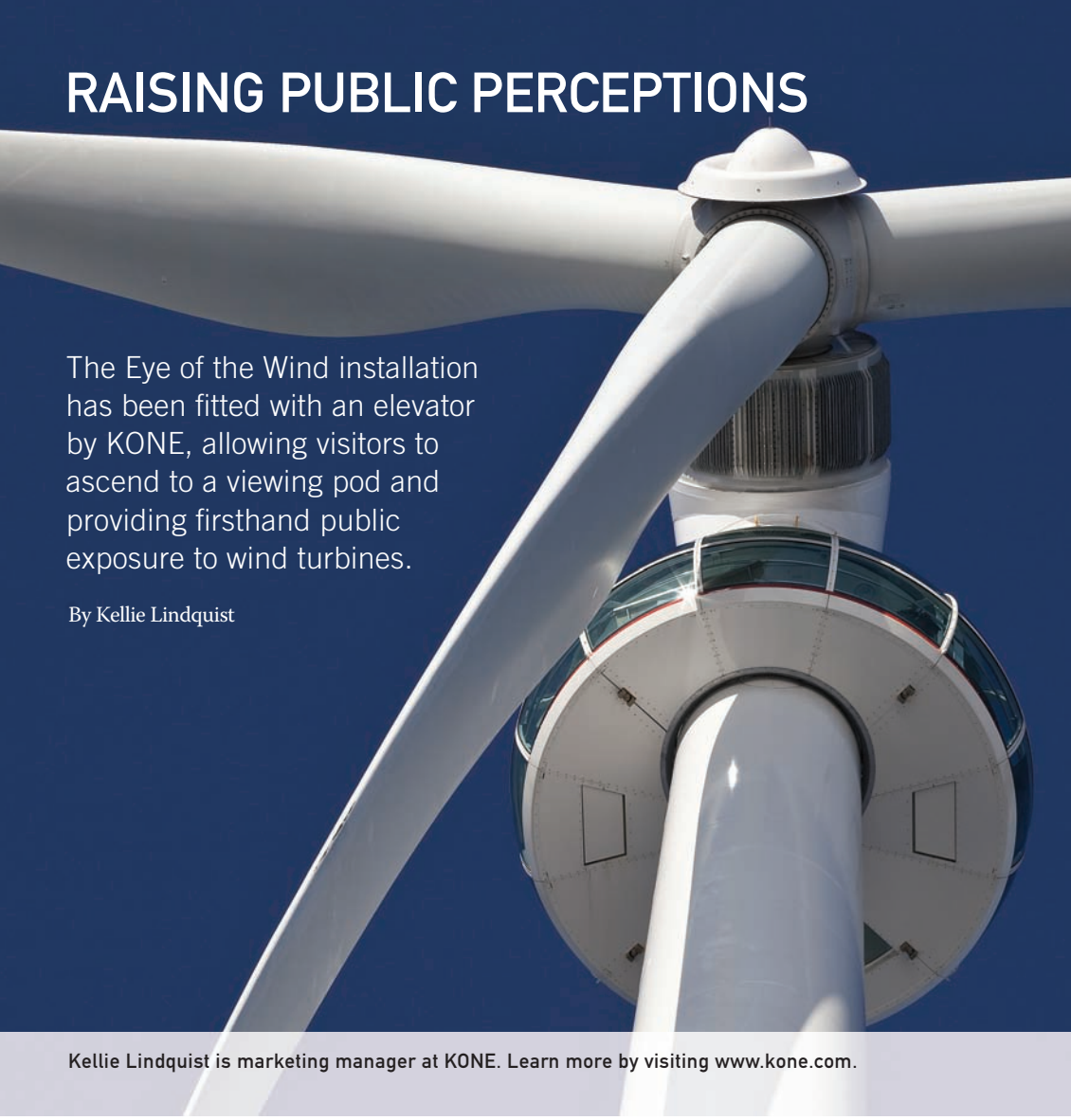
RAISING PUBLIC PERCEPTIONS



The Eye of the Wind installation has been fitted with an elevator by KONE, allowing visitors to ascend to a viewing pod and providing firsthand public exposure to wind turbines.

By Kellie Lindquist

Kellie Lindquist is marketing manager at KONE. Learn more by visiting www.kone.com.

ATOP GROUSE MOUNTAIN—one of the North Shore Mountains in Vancouver, British Columbia, Canada—sits the Eye of the Wind, the world's first wind turbine viewing tower with a public elevator. Built earlier this year, the Eye of the Wind viewing pod transforms the wind turbine from a passive element of the scenic landscape into an interactive, perspective-altering tourist attraction.

For the wind industry, it allows the public to personally experience the true power and potential of wind energy from the perspective of the turbines that harvest it. For the construction industry, the viewing pod is an example of how existing techniques can be used for new and unique projects; even those that pose tremendous challenges.

In this case, KONE lived up to the challenge to build a 20-story elevator for the public, all in a structure that is continuously moving, required protection from earthquakes, and offered one-third the amount of space for a normal elevator. While not every turbine requires a public elevator, the experience proves how teamwork and innovation can help meet even the most challenging obstacles in transporting people safely and efficiently.

GROUSE MOUNTAIN

Grouse Mountain is known for its sustainability platforms, and harvesting energy from the wind was a natural for the developers. But in this case they wanted more than just an indus-

Fig. 1: The Eye of the Wind peers through the evergreens in Vancouver, British Columbia.

trial use for the tower. They wanted to promote the new technology, and to increase demand from consumers for clean energy. "The Eye of the Wind is an iconic symbol of sustainable wind energy that encourages visitors from around the globe to demand alternative energy solutions in their own hometowns," says Chris Dagenais, director of communications for Grouse Mountain.

The Eye of the Wind tower stands 223 feet (65 meters) high and provides a breathtaking scenic view 4,176 feet (1,273 meters) above sea level of Grouse Mountain, recently highlighted during the Vancouver Winter Games.

Each year over 1.2 million people visit Grouse Mountain from around the globe, including Canada, the United States, Japan, Korea, Germany, and the United Kingdom. For these visitors the revolutionary viewing pod represents one of the most recent innovations in eco-tourism, allowing tourists a breathtaking view and the chance to learn about the next generation of energy technology.

CONSTRUCTION

Getting from idea to completion posed many challenges including the turbine's mountaintop location, the size and weight of its components, and the points of origin around the world. The turbine's 122 foot (37.3 meters) blades were airlifted to the peak of the mountain after arriving in Vancouver via barge. Each weighing more than 50 tons, the tower sections arrived at the construction site after a tediously slow trek up Grouse Mountain's eight miles of winding back roads. Even the large, pre-assembled viewPOD™ traveled across Canada on train before arriving in Vancouver.

On top of that engineers had to decide how to house not just the observation pod, but also the elevator that provides access for the public to the Eye of the Wind. KONE was selected for this project, working closely with a number of

Fig. 2: The Eye of the Wind's viewPod provides impressive views of the surrounding mountains and waterways.

different contractors to finish the job on time and successfully.

ELEVATOR PLANNING

The first challenge for the elevator planning was the timing for the entire project. Construction of the entire project required assembling the tower as it arrived in pieces. For engineers this meant that installation of the access elevator could proceed only after the tower was fully erected. For the elevator planning KONE engineers had to take into account the limited space inside the tower, the seismic requirements of Grouse Mountain, and the tower's continuously swinging structure.

Consider these space issues: While the base of the tower measured a standard 13 feet (3.96 meters) in diameter, the tower tapers to just over 6 ½ feet (2 meters) at the top. That space on the top allows for only one-third of the space of an average elevator shaft. To meet those tight require-

ments, the tower was fitted with KONE's MonoSpace® solution, which doesn't require a machine room and is powered by KONE's EcoDisc hoisting technology, allowing engineers to maximize use of the restricted space while ensuring a safe, energy efficient, and comfortable trip to the top.

KONE has pioneered the "machine-room-less" (MRL) technology, allowing more and more commercial, residential, and industrial buildings the advantage of greater design flexibility. With this technique there is no need for the bulky elevator room above the top floor. Such a design would have been impossible at the Eye of the Wind, and it is increasingly falling out of favor in more-traditional structures. In addition, KONE's solution is more energy efficient than traditional technology, another benefit for all structures. This approach is up to 70 percent more efficient than a hydraulic device, and 50 percent more efficient than a traditional traction unit.

After the size of the elevator was determined, engineers turned their attention to Grouse Mountain's location in an active fault region. KONE's Marine Department was called in to help design and implement the structure, as that department has experience with moving structures. In this case, the land on Grouse Mountain is part of an active fault line, so it is literally moving. At the same time, the pressure from the wind and design of the structure itself—which pivots to capture the best winds—means that the structure is constantly moving. The unique solution combines KONE's elevator technology with a seismic installation and an emergency brake release system. All of these features working together provide a safe and efficient manner to visit the Eye of the Wind.

"This project was unique in that it drew on existing technologies but applied them in an innovative way," according to John Hemgard, coordinator of the project at KONE Marine & Major Projects. "So many people worked together to make this happen, from the turbine builder to Grouse Mountain to the local KONE installation team. This was a clear example of how existing KONE technologies were used by the teams, which collaborated and drove the completion of the project."

THE VISITOR EXPERIENCE

The Eye of the Wind gives visitors the chance to experience wind power from a revolutionary perspective. The vast majority of the population is familiar with wind turbines simply through magazine articles, documentaries, or by witnessing them churning away in the distance, but very few people have the

Fig. 3: KONE's compact Monospace elevator systems swoops visitors quickly and safely up the tower to the viewPod, beneath the nacelle.

opportunity to see them in person. Until now, almost no one has been able to experience the harvesting potential from The Eye of the Wind. Overlooking Greater Vancouver's bustling harbor, the pristine Coastal Mountain Range, and the vast, green wilderness of the Canadian countryside, The Eye of the Wind provides visitors with unprecedented 360-degree views from the sky. Visitors begin the ascent to the top with a 35 second elevator ride.

After exiting the elevator, visitors step into the viewPod™, a glass-encased room suspended directly below the hub of the turbine's blades. The room also features a glass segment on the floor, allowing visitors to look down at the ground and fully appreciate the tower's height and magnitude. The experience is described as similar to flying in the clear plexiglas nose bubble of a helicopter, only the viewPod is approximately 30 times larger. Once they have entered it, visitors can literally feel the movement of the giant turbine blades. On a clear day they can see southeast to snow-capped Mount Baker and Mount Rainier, and to the north their sister mountain, Mount Garibaldi. All three are part of the still-volcanic Cascade Range of western North America. Directly to the west and southwest lie Vancouver Island, the Gulf Islands, the San Juan Islands, and the Olympic Mountains. Depending on the time and day, views from The Eye of the Wind may include sunsets, sunrises, and the silver-gray storms that blow in off the Pacific Ocean.

"Days with clear, sunny weather tend to be the most popular," Dagenais says. "However, the public is beginning to realize that days with inclement weather provide the opportunity to see the tower in action, when it is generating electricity."

THE BENEFITS OF TOURISM

The viewPod presents the public with an opportunity to experience the true power of wind energy, making The Eye of the Wind an important educational vehicle for the wind industry. For many years wind turbines have been perceived as the massive, sometimes imposing structures read about in magazines or driven by on the highway, not structures known and enjoyed personally. By providing a face-to-face, intimate glimpse into the wind industry, The Eye of the Wind introduces the concept of wind power to tourists and allows them to get comfortable with the industry as it expands. Individuals take away the grace of the turbine blades circling in the air and the majestic views from the top of the tower. The whole experience dispels the myths and rumors about noise pollution from the blades and amends the public perception of the towers' unsightly nature.

To make that access a reality, the public elevator was necessary to safely and quickly move visitors to the top of the structure. The Eye of the Wind is at the cutting edge of a trend to turn wind turbines into tourist attractions and create additional sources of revenue for wind farm owners. Turbines can now be seen as part of the environments in which they stand, becoming tourist attractions rather than simply accessories to scenic landscapes.

FUTURE OPPORTUNITIES

Throughout the world turbine owners are taking steps to attract curious visitors and educate tourists on the value of wind energy. For example, wind farms are building visitor centers to attract and educate tourists on the value of wind energy. Companies are developing boat tours to take tourists out to sea and visit offshore wind farms in Michigan. Even tourist destinations at remote offshore farms are being conceptualized: one Norwegian design firm's concept, "Turbine City," places a hotel, spa, and cultural museum at the base of an offshore wind turbine.

Already people are paying to visit wind turbines and be photographed with them. At Whitelee, Europe's largest wind farm, over 25,000 people toured the visitor center in its first nine weeks

Fig. 4: Visitors to the Eye of the Wind's viewPod witness the majesty of these structures while noise-related concerns are eliminated.

of operation. The center is located in a fairly remote area of Scotland that has not previously attracted much tourist attention, suggesting that the lure of wind power to tourists is strong.

CONCLUSION

From the project's start to its meticulous finish, The Eye of the Wind has truly become more powerful as a whole than the sum of its parts. The project's turbine, its revolutionary viewing tower, and the access elevator that makes the experience possible symbolize the kind of creativity, innovation, and collaboration taking place in the sustainable energy industry. It is the most recent marketable wind energy advancement and a leading example of eco-tourism to advance the wind energy cause, and KONE is proud of its participation in this project.

< Continued from page 16

2012 and be completed in 2014. Under the terms of the contract CH2M HILL will provide overall program management services and logistical support to ensure that the project remains on schedule.

"CH2M HILL is pleased to assist Tres Amigas with this landmark project," says Don Zabilansky, president of CH2M HILL's Power Group. "The Tres Amigas SuperStation will enable cross-regional marketing of clean electricity, enhance power grid reliability and security, and provide new opportunities for renewable energy producers. This strategic infrastructure program will transform the way electricity is delivered to customers across the United States utilizing the most advanced technology."

Phil Harris—the former CEO of the world's largest transmission balancing area (PJM Interconnection) and CEO and founder of Tres Amigas—says that "The Tres Amigas SuperStation will offer multiple benefits to power consumers and energy producers across North America, including savings projected in the hundreds of millions of dollars due to the more economic dispatch of electric power. Tres Amigas will also increase the value of several large transmission projects planned for the Southwest and will support the expansion of a reliable national corridor system. Tres Amigas is committed to completing the SuperStation in its projected timeline, and CH2M HILL has the expertise and experience needed to ensure that happens. We're pleased that this leading firm will provide Tres Amigas with planning, organization, and logistical support throughout the construction of the project."

The SuperStation project site is at the intersection of the nation's three grids: the Eastern Interconnection, Western Interconnection, and the Texas Interconnection. It will serve as a market hub and balancing authority, enabling the economic transfer of thousands of megawatts of power among the three interconnections. Headquartered in Denver, Colorado, employee-owned CH2M HILL is a global leader in consulting, design, design-build, operations, and program management for government, civil, industrial, and energy clients. Go to www.ch2m.com. Tres Amigas, LLC, headquartered in Santa Fe, New Mexico, is uniting the nation's electric grid as a merchant transmission entity composed of electric utility industry operational, technology, and thought leaders. More information is available at www.tresamigasllc.com.

MOBILECAL ACCREDITED THROUGH A2LA

MobileCal, Inc., has been certified by A2LA (The American Association for Laboratory Accreditation) of Maryland as accredited by certificate number 3040.01 which assures customers that its quality system meets the requirements of ISO 17025 proficiency testing and proves the validity of its documentation and test results. As this scope of accreditation had never been granted previously, MobileCal had to establish new standards before the process of certification could begin. This process delivers heavy industry a new level of quality and process documentation not available before which will improve process resulting in the prevention of large scale industrial accidents and other injuries. The process took about three years to complete, mainly due to the fact there exists no published standards for the calibration of hydraulic and pneumatic torque wrenches of high capacities. Process has been established for decades for the calibration of small sized torque wrenches used in manufacturing and assembly, such as those below 1,000 ft/lbs.

MobileCal's target market is heavy industry, with the majority of their customer's tools being larger in capacity. By adapting established procedures to the larger sized equipment the company was able to bring a higher level of quality and process documentation to the heavy industrial marketplace. Because of their work establishing the new procedures, MobileCal was able to become the world's first accredited organization for mobile calibration of hydraulic and pneumatic wrenches.

MobileCal is the world's oldest and largest provider of on-site calibrations for high capacity torque wrenches. In their five service vans and in-house laboratory they provide calibrations of hydraulic, pneumatic, and manual torque wrenches up to 20,000 ft/lbs for industries such as natural gas pipelines, power generation, wind turbine construction and maintenance, and petrochemical facilities. For more information contact Thomas Smith at (316) 686-3010, or go to www.mobilecal.net.

SIEMENS RECEIVES MAJOR ORDER FOR OKLAHOMA WIND FARM

Siemens Energy has secured an order for the supply of 98 wind turbines for the Crossroads wind power plant in Oklahoma. The owner of the project is OG&E (Oklahoma Gas & Electric). Siemens will supply 95 units of the SWT-2.3-101 to the Crossroads project. Furthermore, the contract includes three units of the new SWT-3.0-101, Siemens' new gearless direct drive wind turbine. The SWT-3.0-101 was launched for sale in America just a few months ago.

Construction of the 227.5 MW wind power

project will begin in late August, with the first wind turbines being delivered in April, 2011. The Crossroads project will be built in Dewey County in northwest Oklahoma, approximately 160 km (100 miles) from Oklahoma City. The scope of supply for the Crossroads wind farm includes the delivery, installation, and commissioning of all turbines. Siemens will also provide services for turbine service and maintenance for an initial period of three and one-half years. Upon completion in the second half of 2011, Crossroads will be able to meet the electrical needs of more than 68,000 average U.S. homes. This is already the third Siemens wind power plant that will provide clean energy to OG&E, following the OU Spirit and Keenan II wind farms, built in 2009 and 2010, respectively.

"We are proud that OG&E has chosen Siemens again as the supplier to their wind power projects," says Jens-Peter Saul, CEO of the Siemens Wind Power Business Unit. "This is the first time that the new SWT-3.0-101 direct drive turbine has been sold in the U.S. Bringing our new generation of direct drive wind turbines to Oklahoma is the first step in establishing this game-changing technology in North America."

"We are excited to move forward this project, which we have negotiated on very favorable terms for OG&E's customers," says Jesse Langston, vice president of utility commercial operations. "By its third year in operation we expect Crossroads to be delivering net savings to our customers for the balance of the projects' 25-year life. This is possible because of the excellent business partnerships we have formed with Siemens, and also due to the constructive regulatory environment we have in Oklahoma."

Wind turbines are part of Siemens' Environmental Portfolio. In fiscal 2009 revenue from the portfolio totaled about EUR23 billion, making Siemens the world's largest supplier of ecofriendly technologies. In the same period the company's products and solutions enabled customers to reduce their CO^2 emissions by 210 million tons. This amount equals the combined annual CO^2 emissions of New York, Tokyo, London, and Berlin. More information is available at: www.siemens.com/energy.

SMART GRID SPENDING TO TOP $45 BILLION BY 2015

Cumulative global investment in smart grids—including smart meter implementations, as well as upgrades to the transmission and distribution infrastructure—will approach $46 billion by 2015 according to the latest forecasts from ABI Research. A smart grid is an energy generation, transmission, and distribution system equipped with an advanced two-way communications system that allows for greater visibility, control, and automation over the system for the utility operator. Simultaneously, it provides a greater level of energy usage choice and automation for customers. It's that communications system that makes a grid truly "smart" because it allows for the real-time monitoring of the current operational state of the network, as well as the ability to respond to those conditions automatically, as quickly as possible.

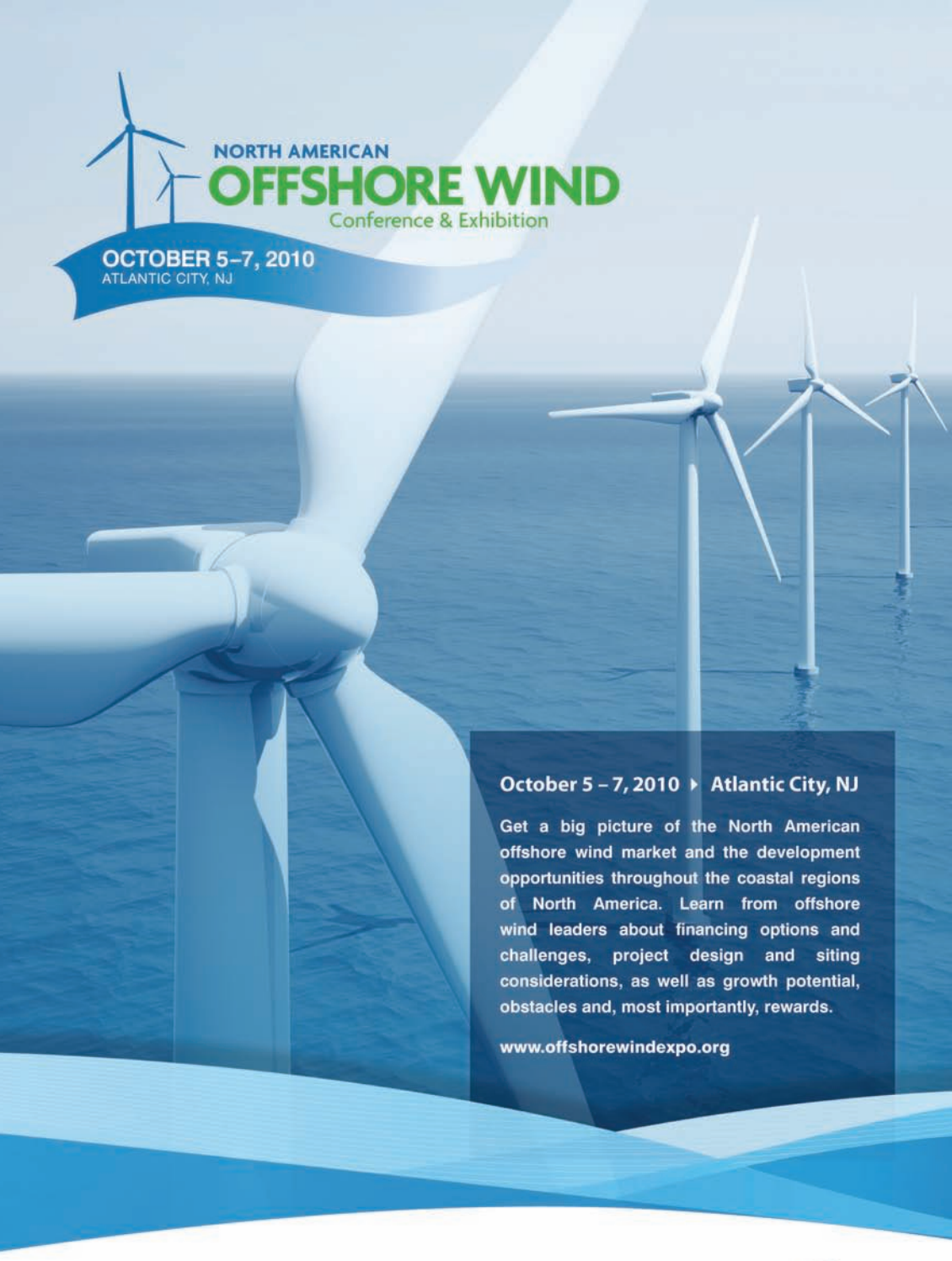
Larry Fisher, research director of NextGen, the ABI Research unit that published this study, says "Most of the electric utility infrastructure deployed in the industrialized world was built between 60 and 80 years ago. Much of this infrastructure is outdated, and with the continuing increase in demand for power year after year the grid cannot safely and reliably manage the loads of today and tomorrow without significant upgrades."

The groundwork for smart grids has been laid in a number of countries over the past several years, but the pace of investment and implementation is increasing. "Transmission and distribution (T&D) investments will account for the lion's share of smart grid investments through 2015," Fisher says. "On a cumulative basis, a total of almost $41 billion will be invested globally in the electrical transmission and distribution infrastructure through 2015, compared to $4.8 billion for the purchase and installation of smart meters. This infrastructure spending will focus on grid automation and control, distribution automation, distributed generation and demand response programs."

ABI Research's new study "Smart Grid Applications: Smart Meters, Demand Response, and Distributed Generation" forecasts the market for smart grid equipment and services for the 2010-2015 period covering North America, Europe, the Asia-Pacific region, and selected other countries. For more information call (516) 624-2500 or visit www.abiresearch.com.

GROUNDSMART PRODUCTS FROM COMMSCOPE

CommScope introduces GroundSmart grounding products into its BiMetals family of wire and cable solutions. These products help reduce the costs of managing and maintaining electricity transmission and distribution networks by deterring theft and vandalism. CommScope's use of copper-clad steel in its GroundSmart products provides a safe, highly



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reliable alternative to the use of solid and stranded copper for grounding applications. These products are specifically designed to disperse fault currents and lightning strikes at a lower total cost of ownership compared to pure copper. GroundSmart products offer proven performance for optimizing grounding design in substation, distribution and transmission systems, as well as in wind and solar farms.

"A survey published last year estimated that theft of copper wiring from electrical utility sites creates more than 7,500 hours of downtime and costs the industry more than $60 million annually," says Paul Bedder, vice president. "Copper-clad steel wire and cable products provide the same reliability, performance, and durability as solid copper but are unattractive to would-be thieves and vandals.

"These facts alone make copper-clad steel the smart alternative to solid copper in most grounding applications," he continues. "The advantages of this solution increase when combined with CommScope's reputation for service and reliability. GroundSmart users realize long-term benefits when repairing their current systems damaged by theft and vandalism or when bringing online new systems such as wind and solar farms."

CommScope's copper-clad steel wire and cable products meet the relevant National Electric Code (NEC) and ASTM wire and cable standards and are approved by the Rural Utilities Service (RUS). They are engineered and manufactured at CommScope's ISO 9001 and ISO 14001 registered facility in Statesville, North Carolina.

CommScope, Inc., is a world leader in infrastructure solutions for communication networks. Through its Andrew Solutions brand it is a global leader in radio frequency subsystem solutions for wireless networks. Through its SYSTIMAX® and Uniprise® brands, CommScope is a world leader in network infrastructure solutions, delivering a complete end-to-end physical layer solution, including cables and connectivity, enclosures, intelligent software, and network design services for business enterprise applications. CommScope also is the premier manufacturer of coaxial cable for broadband cable television networks and one of the leading North American providers of environmentally secure cabinets for DSL and FTTN applications. Backed by strong research and development, CommScope combines technical expertise and proprietary technology with global manufacturing capability to provide customers with infrastructure solutions for evolving global communications networks in more than 100 countries around the world. More information is available at www.commscope.com.

ONSITE SOFTWARE UPGRADE FROM WINDLOGICS

WindLogics has released OnSite 3.1, a software upgrade to its existing data management system. The OnSite system enables wind energy developers and operators to remotely monitor their met towers and maximize the value of their wind measurement investment. The upgrade provides enhanced functionality in response to customer feedback, including the dynamic generation of wind roses and the ability to attach documents to a met tower's record.

The OnSite system can quickly detect changes in a wind sensor's "health" status and send relevant data and alerts directly to a met tower's owner. Continual data quality checking ensures that problems with equipment are promptly resolved, thereby increasing the value of met tower data for use in formal, bank-worthy assessments. More than 700 met towers have been enrolled on the system since 2005. Currently OnSite is used to manage met towers representing more than 30,000 MW of future wind projects, equivalent to three times the amount of wind power installed in the U.S. during 2009.

OnSite automatically collects, processes, and securely stores wind data gathered from each tower. It also includes Web-enabled user interfaces that allow customers to enter or view tower information, including configurations and maintenance history, and examine quality-checked data from any combination of sensors and towers. Staff meteorologists and wind energy analysts are available to assist with questions or provide additional support as part of WindLogics' full spectrum of wind energy services.

"We assist many different types of customers with our OnSite service. Landowners with a couple of towers appreciate the peace of mind that results from our secure data storage and find the overall service to be a great value," says Mike Coriale, product manager. "Larger wind energy developers find our new fleet-wide tower status reports essential in monitoring the health of tens or hundreds of towers."

WindLogics is a renewable energy consulting services firm that combines leading scientific analysis with deep expertise in the planning, development, and operation of renewable energy projects. It is a wholly owned subsidiary of NextEra Energy Resources. For more information e-mail sales@windlogics.com or visit www.windlogics.com.

ADINDEX

Mike Couling
President/Redstone College

WHAT LED TO THE DEVELOPMENT OF YOUR NEW WIND ENERGY TECHNOLOGY PROGRAM?

Redstone College, which was formerly known as Colorado Aero Tech, has been around for about 45 years, and we offer technical programs such as "Airframe and Powerplant" and "Advanced Electronic Technology." We provide a "Construction Management" program for that industry, and "Heating & Ventilation, Air Conditioning & Refrigeration" in the industrial services category, so we have a long history of offering training programs targeting a wide variety of fields. We're one of the nation's top providers of newly FAA-certified aircraft mechanics, in fact, and we've graduated more than 15,000 technicians over the years. A couple of years ago we were briefed by Snap-on Tool executives about the growth of the wind power industry here in the United States and around the world, and we discussed their plans to be a major tool supplier for the industry. After much research we decided the time was right to introduce a training program for wind technicians. We sought the input of industry giants, including Vestas, which has three manufacturing facilities nearby, and also the American Wind Energy Association, which we've joined, and we're pulling together a professional advisory committee to help us keep our curriculum current in the coming years. It has been our goal from the very beginning to have a great deal of involvement and interaction with the key players in the wind industry.

WHO IS ELIGIBLE TO ENTER THE PROGRAM, AND WHAT WILL THEY LEARN?

First of all, anyone can apply as long as they have a high-school diploma or have passed their GED. We had more than 60 people apply for the first class, which began its program of study on August 5 and will last for 15 months, and they were made up of everyone from recent high-school graduates to those in mid-career who are interested in developing new skills and making a change. The program is divided into six terms, and in the beginning students will learn the basics of electrical theory before taking an introduction to wind energy in the third term, which discusses its history as well as the mechanics and design of turbines and towers. During the remaining three terms we'll really get into the heart of the matter, including the design of wind turbines, blades, pitch, rotors, and other mechanisms, and then we'll cover more having to do with electronics such as AC/DC fundamentals, solid state theory, and digital electronics. Toward the end of the course we'll get into inspection and troubleshooting, and then we'll conclude with wind turbine safety training, including climb and fall safety, emergency rescue, fire safety, and CPR. Those completing the program will receive an associate of occupational studies degree, along with any certifications they require.

TELL US ABOUT YOUR FACILITIES, AND WHAT WILL BE AVAILABLE FOR STUDENT TRAINING.

Knowing that Vestas is such a big player in the wind industry worldwide, we wanted to have equipment that would provide the best hands-on training, so we purchased a previously-owned Vestas V-27 225kW turbine. We have the nacelle on the ground so that it can accommodate larger classes, and we also have a 33-foot section of tower where we'll conduct different safety exercises. As for employers, we feel that we'll be a great resource for the industry, providing manufacturers, O&M providers, and many others with qualified technicians from our centrally-located campus here in Denver, Colorado. With our proven track record in the aviation industry, and the tremendous growth of the wind industry both here in North America and abroad, we look forward to playing a role in supporting the growth of the renewable energy market. In fact, the latest stats provided by AWEA state that a new wind technician is needed for every newly installed 10MW of wind capacity. In 2009 over 500 new technicians would have been needed. With the current U.S. initiative of reaching 20 percent electricity from wind energy by the year 2030, some 30,000 new technicians will be needed. Redstone College is excited about the growth of this energy segment, and we stand ready to train these new technicians.

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