



Giving Wind Direction

WIND SYSTEMS

LUBRICATION & FILTRATION, TURBINE FOUNDATIONS

**Lubrication & Filtration,
Turbine Foundations**

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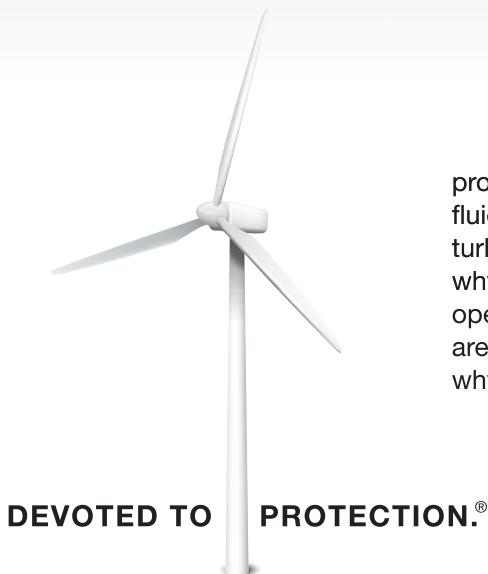
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Company Profile: C.C. Jensen

Offline filters by C.C. Jensen keep the 'life blood' of wind turbines clean and pumping.

By Justin Stover

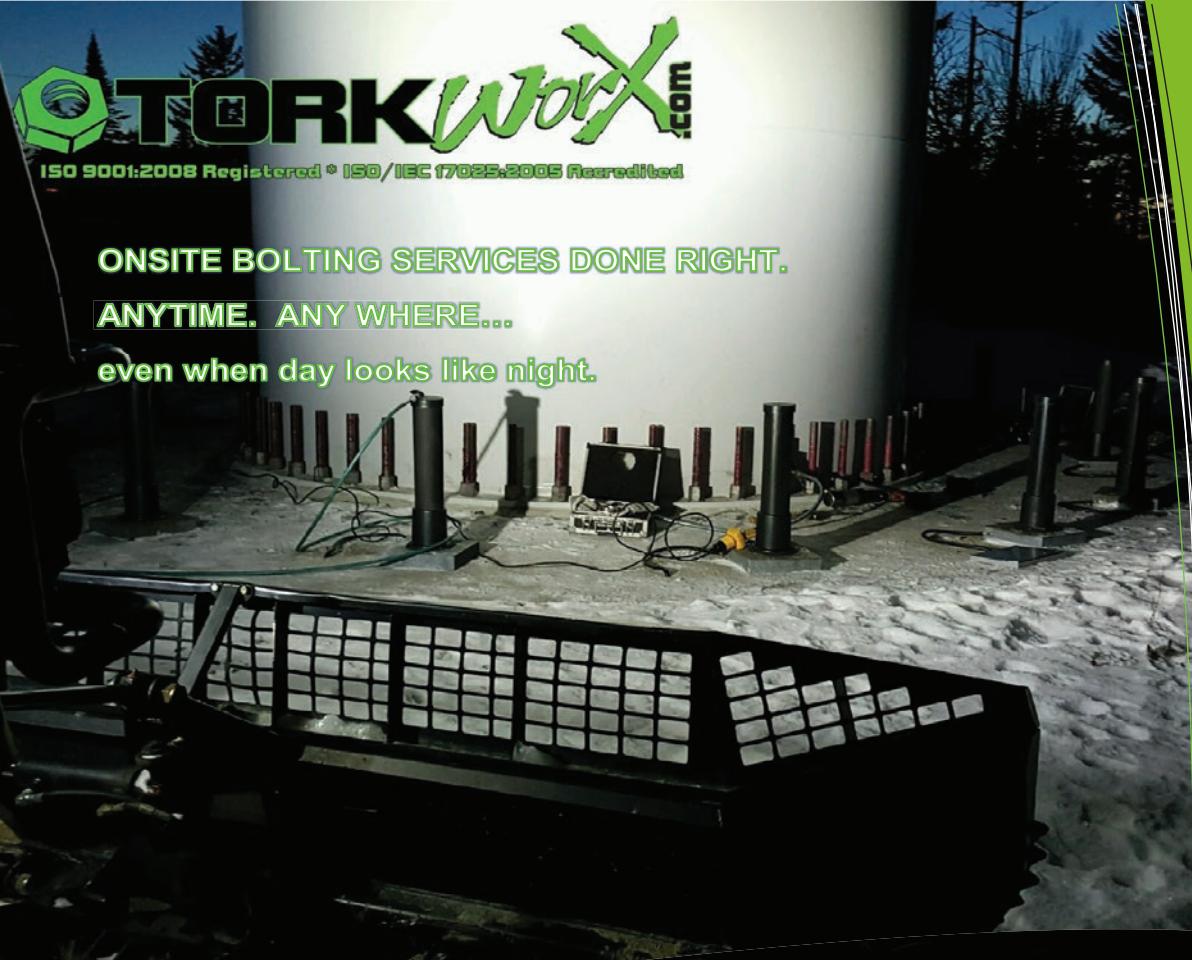
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EDITOR'S DESK

Spreading the Word about the Multi-Faceted World of Wind

In 2001, I traveled to Southern California. While driving through Palm Springs near dusk, I was awestruck by the sight of hundreds of wind turbines silhouetted against the desert's magenta sky.

I had never seen such a technological achievement before, and that image has stuck with me as one of the coolest things in recent memory.

Fast forward 15 years, and I find myself immersed in the world of wind, but this time I get to see it from the inside and the other side.

Despite having decades of editorial experience under my belt that includes a lot of writing on technology, the wind industry necessitated a bit of a learning curve when I became managing editor of *Wind Systems*.

Since then, I have thrown myself into a whirlwind of knowledge — every pun intended. I certainly never realized how much labor and technology across dozens of companies go into planning, building, and maintaining just a wind turbine alone. Then those turbines get multiplied and spread across a landscape forming the futuristic orchard that makes up a wind farm, and the intricacies of operating and creating electricity from wind multiplies exponentially.

Which brings me to the August edition of *Wind Systems*.

In this month's issue, we focus on perhaps some of the unsung heroes of the wind industry: companies that deal with lubrication, filtration, and turbine foundations. The squeaky wheel gets the grease, or in this case, the squeaky bearing. If the inner workings of a turbine start to crumble, then that can eventually cascade into financial catastrophe.

That's why the wind industry depends on companies that can supply lubricants and filtration systems to maintain turbines and stop problems before they happen. One need only to look at what C.C. Jensen has done for filtration systems to see how important this function is. This issue's company profile looks at C.C. Jensen. It is a leader in filtration and lubrication for wind-turbine systems. It offers offline filtration systems that help keep wind turbines running smoothly and repair costs down.

On the subject of lubrication, Klüber offers up its expertise on when and where to use the right lubrication. The solution may be surprising.

Of course, keeping a turbine running is a moot point without a turbine foundation. RUTE Foundation Systems is developing new foundation technology that will cut the concrete used in foundation building by three-fourths. These companies and many more ensure the wind industry will spin on strongly into the future.

Yes, I've had to learn a lot in my first month at *Wind Systems*, but I'm not an expert — yet. So far, my learning curve seems to be bottomless. And because of that, I still find myself awestruck by how far the wind industry has come since I first set eyes on those shadowed, spinning towers on the West Coast.

AUGUST 2016



Kenneth Carter, managing editor

Wind Systems magazine

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A handwritten signature in black ink, appearing to read "Kenneth Carter".

CONTRIBUTORS

Justin Stover holds an AAS Degree in Fluid Power Technology. He is sales manager at C.C. Jensen, Inc. Stover has published papers on gearbox contamination control, offline oil filtration, methods for water removal from lubricants, and varnish removal by adsorption. Stover has achieved certification as a Level II Machine Lubricant Analyst (ISO 18436-4, II) through the International Council for Machinery Lubrication. His industry activities include serving on the AGMA Wind Turbine Committee and over the last five years has been active within the Society of Tribologists and Lubrication Engineers (STLE).



Travis Dees is the Wind Division director at World Wind & Solar (WWS), an energy service provider in the renewable energy sector. Providing complete services from met towers to electrical construction through operations and maintenance, the company also provides staffing and QA/QC services for both the wind and solar industries. WWS services all major turbine and panel manufacturers at scores of renewable energy facilities throughout the United States from New Hampshire to Hawaii. For more information, go to www.worldwindsolar.com.

FROM OUR ARCHIVES

REACHING NEW HEIGHTS

Could wind drones be the next evolution in wind power generation?



WIND ENERGY: A LONG-TERM PASSION
NREL's 91-year-old senior engineer still actively involved following an established career in wind research



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Dong Energy to Build Dutch Offshore Wind Farms



Dong Energy A/S

Dong Energy will build the Netherlands' offshore wind farms Borssele 1 and 2, according to the Netherlands' Minister of Economic Affairs.

Dong Energy won the concessions with an average bid strike price, excluding transmission costs of 72.70 euros per MWh during the first 15 years of the contract. After that, the wind farms will receive the market price.

Four years ago, Dong Energy set a 2020 cost target of reaching 100 euros per MWh over the lifetime of a wind farm — the leveled cost of electricity — including transmission costs. This target, which was

later adopted by the offshore wind industry, has been reached.

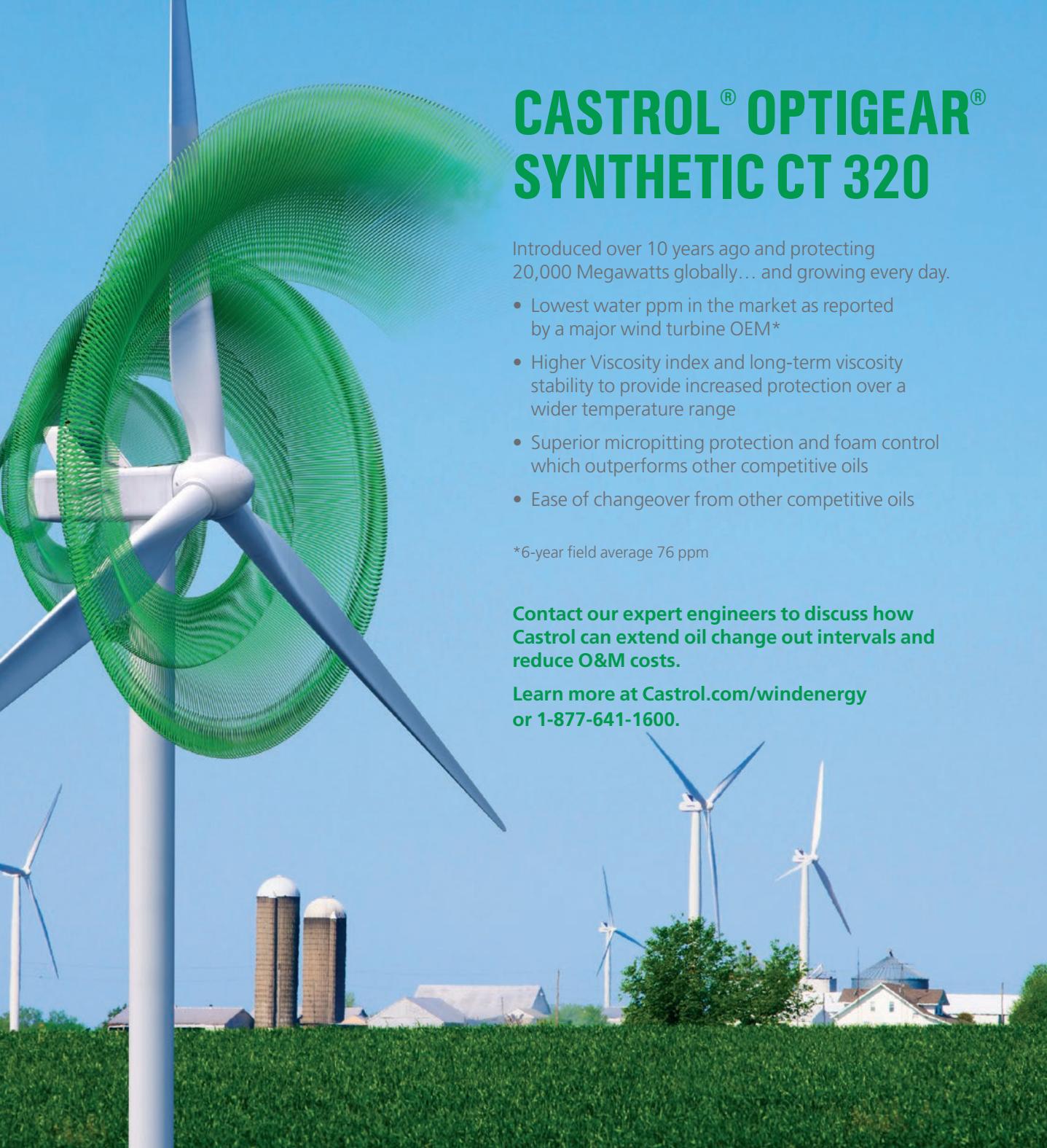
"Winning this tender in a highly competitive field of bidders is another proof of our market-leading position and our business model that builds on continued innovation, industrialization, and scale," said Samuel Leupold, executive vice president and head of Wind Power at Dong Energy. "With Borssele 1 and 2, we're crossing the leveled cost of electricity mark of 100 euros

per MWh for the first time and are reaching a critical industry milestone more than three years ahead of time. This demonstrates the great potential of offshore wind."

Dong Energy offshore wind turbines

Dong Energy will, in accordance with the Dutch tender regulation, build Borssele 1 and 2 within four years with a flexibility of one year. The wind farms' capacity of two times 350 MW will translate into a supply of carbon-dioxide-free electricity covering the annual power consumption of about 1 million Dutch households.

"The Dutch government has introduced an ambitious, long-term development plan for offshore wind," said Jasper Vis, country manager for Dong Energy Netherlands.



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"The Borssele concessions mark a milestone in the Netherlands' shift toward green energy, and we look forward to bringing our more than 20 years' experience with offshore wind into these projects."

The reduction of cost of electricity is driven by cross-industry collabora-

ration, ongoing innovation of wind turbines and blades, continuous improvements of foundation design and installation methods, higher cable capacity, a growing and competitive supply chain, and the synergies from building large-scale capacity sites such as Borssele 1 and 2. In addition,

the Dutch sites offer good seabed conditions as well as good and stable wind speeds, which contribute to high output from each turbine. ↗

Source Dong Energy

For more information go to: www.dongenergy.com.

Siemens to Supply 141 Turbines in New Mexico and Texas

Siemens has contracted with Pattern Energy Group LP to deliver, install, and service 141 wind turbines for the Broadview Wind project. Broadview Wind combines two adjacent projects in New Mexico and Texas with a total installed capacity of 324 MW. Both onshore wind-power plants will provide clean energy to meet the energy needs of about 180,000 households.

Siemens' installation of its 2.3 MW onshore wind turbines was scheduled to begin in July, with the start of operations expected in the fourth quarter of 2016. A long-term service and maintenance agreement also was signed for the turbines and includes Siemens' remote monitoring and diagnostic services, which offer a proactive approach to service and maintenance to help bolster the performance of the turbines during their lifetime.

Siemens will deliver its SWT-2.3-108 wind turbine, with a rotor diameter of 108 meters and a hub height of 80 meters. An installed power boost option provides additional electrical output under high-wind conditions. The New Mexico section of the Broadview project — near Broadview, an unincorporated community in Curry County in east New Mexico and about 29 miles north of Clovis — will feature 105 turbines for a to-

tal of 241 MW. The Texas section — in Deaf Smith County, about 100 miles southwest of Amarillo — will have 36 turbines for a total of 83 MW. Both sites benefit from constant wind conditions related to the streams of the North American wind belt. The blades for this project will be manufactured at the Siemens blade facility in Fort Madison, Iowa. The nacelles and hubs will be assembled at the Siemens facility in Hutchinson, Kansas.

Siemens Financial Services (SFS) division is supporting the project with loans totaling nearly \$100 million. The funds provided by SFS will be used to support the customer's equity stake in the transaction — both during and after construction.

"Siemens is proud to provide a sustainable solution to Pattern Development to help advance efforts in the U.S. to reduce greenhouse gas emissions," said Thomas Richterich, CEO Onshore of the Siemens Wind Power and Renewables division. "With our broad portfolio and comprehensive expertise in wind-power generation, we will help to increase the share of wind power in the U.S. energy mix. With New Mexico's proximity to important wind-energy areas, the state is on the way to become an important driver for the wind industry in this region." ↗

Source Siemens

For more information, go to www.siemens.com/wind.



The Broadview project includes 141 units of type SWT-2.3-108 for New Mexico and Texas.

Wind Saves Ireland 70 Million Euros in 6 Months



Wind energy has saved Ireland about 70 million euros in foreign-energy imports since the beginning of 2016, a six-month period that saw the indigenous renewable energy source meet more than a fifth (22 percent) of Ireland's entire electricity demand, according to provisional new figures compiled by the Irish Wind Energy Association.

This figure puts Ireland almost on par with other leading EU Member States such as Spain where wind energy produced 23.6 percent of Spain's power in the six-month period and puts Ireland ahead on a percentage basis of countries such as Germany where wind and solar contributed some 20 percent to their domestic power demand in the first half of 2016.

"While it's exciting to see wind energy delivering such high levels of electricity generation, it's critically important that we continue to focus on developing these clean and indigenous energy sources and focus on reducing our dangerously unsustainable 85-percent reliance on expensive fossil fuel imports," said Brian Dawson, head of communications for IWEA. "Apart from easing our dependency on fossil fuel imports, wind energy is delivering real tangible value to electricity consumers, is promoting significant investment and jobs in our communities, and is helping to protect our environment for future generations."

"Public interest in wind energy as a clean renewable energy for Ireland is also high," he said. "We always encourage people with questions about wind energy to visit wind farms for themselves, and this June saw 1,500 people young and old visiting local wind farms, seeing the turbines in action and learning about the benefits of this home-grown Irish energy."

The peak for the period in terms of wind-energy production was recorded on January 28 when wind-energy output

A recent survey showed 70 percent of the people support wind energy in Ireland.

hit 2,132 MW for Ireland, representing almost 60 percent of electricity demand at that time.

In addition, the overall level of wind-energy capacity in Ireland has just reached a new all-time record peak of 2,500 MW, which has the potential to create enough electricity to regularly power more than 1.6 million homes.

Ireland imports 85 percent of its energy, 35 percent above the European average, just behind Malta, Cyprus, and Luxembourg.

A recent national survey showed 70 percent of people support wind energy in Ireland, and this interest in Irish wind energy was further highlighted in June with more than 1,500 people visiting wind farms across Ireland and Northern Ireland in June.

2017 will mark 25 years since the first Irish wind farm started generating electricity. Today there are more than 200 wind farms in Ireland, with the wind-energy sector employing more than 3,400 people nationwide, a figure that is projected to grow to more than 8,000 by 2020.

The Irish Wind Energy Association was established in 1993 and is the national body representing the wind-energy sector in Ireland. IWEA is committed to promoting the use of wind energy in Ireland and beyond as an economically viable and environmentally sound alternative to conventional generation and promotes awareness and understanding of wind power as the primary renewable energy resource. ↗

Source IWEA

For more information,
go to www.iwea.com.

inFOCUS

Profile: C.C. Jensen

Offline filters by C.C. Jensen keep the ‘life blood’ of wind turbines clean and pumping.

By Justin Stover

The foundation of effective wind-turbine asset management begins with clean oil.

C.C. Jensen is the worldwide leader in providing clean oil for wind turbines through the use of offline filters.

Founded in 1953, C.C. Jensen has provided offline filters for heavy industries, including wind-power, to achieve one singular goal — cleaner oil.

Over the past 20 years, C.C. Jensen's approach has changed how wind-power OEMs, owners and service providers manage and monitor lubricants to achieve great reliability.

THE HISTORY

One day in the late 1930s, an assistant engineer on board the motor vessel Marchen Maersk witnessed a phenomenon that would eventually benefit wind turbines the world over. During his rounds in the engine room, he had kept a watchful eye on oil leaks coming from a pipe connection in the engine's lube oil system.

On this particular day, he observed these leaks closely and happened to see a drop of oil fall on the back of his hand. This was no ordinary drop of grimy oil. What struck him was how clean and bright this amber drop was.

At the same time, he knew the oil flowing through the pipes was pitch black as a result of blow-by and soot contamination. Changing the oil several times, he was accustomed to seeing oil that was dark and contaminat-

ed. Carl Jensen had a curious mind, so he looked up to identify the source of this golden drop.

He saw the drop had pressed out through a pipe-flange connection. Looking closer, he took note that this connection had a gasket seal. That was his lightbulb moment — the humble gasket had acted as a filter.

With a keen eye for innovation and reliability, that was his moment of inspiration. Since then, this story has been told many times. Often it is embellished to include a slightly more dramatic version with the oil drop hitting him right on his nose.

Whether it was on the back of the hand or on the bridge of his nose, Jensen invented a product that would eventually save millions of dollars for wind-turbine OEMs and owners. Today, nearly 80,000 wind turbines use C.C. Jensen offline filters to extend gear and bearing life, increase time between costly oil changes, and optimize the power output of wind turbines.

Over the years, the core concept of C.C. Jensen has not changed — low flow through a depth media. This approach has been delivered in the best and most practical way: offline filters.

Most wind turbines now have a so-called inline filter. It is located in series with the oil cooler.

In order to keep oil temperatures down, a higher quantity of oil needs to be pumped every minute. But at higher flow rates, an inline filter needs to be relatively large. In prac-



tice, the inline filters are typically coarse and release particles captured during frequently occurring starts and stops.

Offline filters by contrast can filter out much smaller particles because the flow rates are lower. Tiny particles cause the most damage and are in much higher concentrations. No problem for an offline filter.

At the same time, offline filters provide reliable removal of water



C.C. Jensen

contamination and oil-degradation byproducts.

THE CHALLENGE

Gearboxes that run dirty usually have short lives. Gears, bearings, and the lubricant all suffer greatly from contamination.

In the late '90s, widely publicized news accounts shined a light on gearbox failures. Many manufacturers now acknowledge the gravity of the

A filter unit installed on a Siemens 2.3 MW turbine.

problem and factory-fit or retrofit of fine filters.

It has long been recognized that clean oil will improve the reliability and lifetime of gears and bearings. Therefore, it is ironic that many wind turbines still are sold without filter systems capable of maintaining clean gear oil.

ALSO IN THIS SECTION

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David DiNunzio – Castrol

C.C. Jensen



A gear-filter insert.



C.C. Jensen

C.C. Jensen is a family-owned international company established in 1953 and based in Denmark.

Not all gearboxes suffer from severe contamination, but all gearboxes should have contamination control systems in place that will give the gears, bearings, and oil a fighting chance to survive. C.C. Jensen is the world leader for such systems.

THE IMPORTANCE OF CLEAN OIL

About 80 percent of all breakdowns in lubricated machines are related to contamination in the oil. Research going back nearly four decades dependably established gear and bearing life can be increased up to seven times simply by upgrading the filtration system of a gearbox.

For instance, in 1979, a groundbreaking study at London's Imperial College proved that rolling element bearings in gearboxes can have a life-extension factor of six by upgrading the filter system from a 40-micron to a 3-micron filter.

One of the conclusions from their research was: "Replacing 40-25 micron filters by units rated at 3 microns absolute is to be recommended for gearboxes. Such action should lead to improved reliability, longer periods between overhaul, cheaper overhauls, and consequent reductions in ownership costs. Times between oil changes, where relevant, should be substantially increased." C.C. Jensen fills that need with offline filters rated at 3 microns absolute that are affordable, compact, and easy to install.

WHY CUSTOMERS USE C.C. JENSEN

Clean oil saves money. Average ROI is less than three months. Extending oil life by a factor of three saves \$95,000 over the life of the turbine. Improving gear and bearing life by a factor of three will save \$250,000. Clean oil is also good for the environment. Oil is a resource that

C.C. Jensen



Before and after oil results.

needs to be cared for and managed responsibly. Less oil waste reduces the carbon footprint for wind farms, making wind energy even greener.

Working with customers worldwide, C.C. Jensen delivers products and consulting services in multiple languages in most countries using wind power. For organizations with a global reach, it can support a customer's efforts basically anywhere.

Being a clean-oil expert, C.C. Jensen has an experienced global team focused on getting results. It sees all types of oils and all types of turbines first hand. It provides training and consultative services for wind-turbine OEMs and owners, big and small.

C.C. Jensen's offline filters deliver — as testified by more than 80,000 wind turbines running with clean oil worldwide.

TODAY AND MOVING FORWARD

C.C. Jensen's offline filters and superior filter inserts are available through a global network of sales offices and dedicated support teams.

In day-to-day dealings with C.C. Jensen, customers experience a commitment to service. C.C. Jensen's employees do their utmost to provide the right solution — every time.

With the number of wind turbines expected to double by 2020, C.C. Jensen is ready and poised to support OEMs and owners to efficiently manage wind-turbine assets. The company maintains a stock of offline filters and associated spare parts to ensure smooth operations and maintenance for years to come. ↗

For more information on C.C. Jensen, go to www.ccjensen.com.

WHAT IS AN OFFLINE FILTER?

A system of filtration in which a portion of the total oil volume passes through a filter having its own circulating pump operating in parallel to the main system.

The word "offline" can mean different things in the power-generation business. Offline to a power-plant operator generally does not create a warm and fuzzy feeling. As it relates to filtration, offline is an important distinction because it identifies where and how a filter operates. The term offline simply refers to the fact the filter operates completely independent of the machine on which it is installed. While critical to the overall function and health of the machine, the offline filter is designed to run on its own. In a wind-turbine gearbox application, the offline filter will operate continuously, pulling oil from the gearbox, purifying it and returning it to the gearbox through an available port. This takes place

whether the wind turbine is spinning or idle. This ensures clean and dry oil is available at critical starts and stops when the gearbox is most vulnerable to damage.

A common phrase to describe an offline filter is a so-called "kidney loop" filter. As the name implies, the filter operates similar to a dialysis machine that filters the blood of a patient with failing kidneys. This "kidney loop" process involves drawing oil out of the dirty system and passing it through highly efficient filters to remove contaminants. Offline filtration units are simple. Typically they include a robust electric motor and a highly dirt-tolerant gear pump that pushes oil through a fine filter element.

Since oil is often referred to as the lifeblood of a gearbox, it is fitting that "kidney loop" or offline filters are employed to keep lubricant health in optimum condition.

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Klüber Lubrication

Since each rolling bearing in a wind turbine operates under different conditions, it often is assumed using a variety of lubricants is essential for serving all of them.

For operators, this means not only added logistical efforts and expensive warehousing but also the increased risk of product mix-ups.

Some newly developed greases can be used for all rolling bearings in a wind turbine. Often, they not only meet all requirements of main, generator, yaw, and rotor-blade bearings, but they also increase the turbine's operational reliability considerably. Combined with a white adhesive lubricant used for the open yaw and

pitch-blade gears, only two special lubricants are needed to cover all relevant, grease-lubricated friction points in a wind turbine.

WIND-POWER PLANT LUBRICATION

The most important bearings in a wind turbine — such as the main, generator, yaw, and blade bearings — each operate under different conditions, leading to different requirements for the lubricant.

Operators of wind-power plants frequently have to use different types of grease to satisfy each requirement. Additionally, service companies have to take into account different lubri-

While friction will never be eliminated fully, single-use lubricants can cover all relevant grease-lubricated friction points in a wind turbine.

cant recommendations for each turbine manufacturer and turbine model. The result is increased expenses for logistics, warehousing and grease disposal, as well as the constant risk of lubricant mix-up. Certain lubricants also may not be available in some locations worldwide.

ONE SOLUTION

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The main bearing is one of the most important bearings in a wind turbine.



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If a damaged generator bearing causes damage to the generator itself, repair and replacement costs will be in the thousands of dollars.



Klüber Lubrication

Another set of lubricant-demanding components in wind turbines are the yaw and blade gears with their open teeth.

A single-use lubricant, consisting of a special mix of base oils and a purpose-developed additive package, includes a service temperature range of minus-40 to 150 degrees Celsius. This is attained through a mix of synthetic and mineral base oils, allowing the lubricant to remain stable at higher temperatures and giving the bearing a longer life.

Any product containing only mineral oil likely would fall short of these requirements. With a wider range than the actual temperatures in wind turbines, it can offer some reassuring reserve capacity, leading to slower grease aging and longer relubrication intervals.

Wear also occurs while the turbine is standing still or running at low speed, since a sufficient hydrodynamic lubricant film cannot form under these

conditions. To counter this effect, a single-use lubricant can be fitted with suitable additives to prevent damage, even if the damage is caused only by vibrations.

Other critical factors for trouble-free wind-turbine operation include good pumpability in accurate quantities with centralized lubricating systems, as well as good grease distribution and defined oil release.

Single-use lubricants offer good compatibility with all commercial sealing elastomers. Comprehensive tests have shown that due to its specific combination of base oil and thickener, any mixing with other bearing greases does not cause critical reactions, which makes lubricant changeover much easier.

COST COMPARISON

The costs from bearing damage should not be underestimated. In addition to material and labor costs for replacing a damaged bearing, operators also must consider possible lead time for parts and/or tools, and the loss of production.

These factors combined can contribute to a steep increase in costs. For example, if a damaged generator bearing causes damage to the generator itself, repair and replacement costs will be in the thousands of dollars. In comparison, the cost of a single-use lubricant that helps improve plant reliability and avoid unplanned downtime are all but negligible.

THE WORK OF A MULTITUDE OF GREASES

Another set of lubricant-demanding components in wind turbines are the yaw and blade gears with their open teeth. At many sites, one-wind direction is dominant, and the pitch angle remains relatively similar. This leads to only a small portion of the gear teeth being in contact a majority of the time. The transmission of power to adjust the nacelle and blades often are limited to only a few teeth.

Lubricants of extremely high load-carrying capacity offer elevated and reliable protection against wear. Apart from that, gear teeth not in mesh have to be protected against corrosion.

Most open gears in wind-power plants are still lubricated by hand. However, maintenance has to be reduced in order to keep downtime to a minimum. For this purpose, central lubrication systems are used increasingly for the relubrication of the open gears. These adhesive lubricants, which by their nature are viscous, have to ensure good pumpability even at low operating temperatures.

ADDED-VALUE CONCEPT

While friction will never be eliminated fully, single-use lubricants can sufficiently cover all relevant grease-lubricated friction points in a wind turbine. This added-value concept has proven successful in many wind-power plants for several years. It allows plant operators to make maintenance routines easier and reduce storage costs. Due to the high performance of single-use lubricants, downtime can be reduced and the effectiveness, and hence the yield, of wind-power plants can be increased. ✎

*Source Klüber Lubrication NA LP
For more information, contact Jesse Dilk or Jestin Hulegaard with Klüber Lubrication at www.klueber.com.*

Cutting the Concrete

New foundation technology will lower use of concrete in wind-turbine towers by 75 percent.

An Oregon startup is developing a new foundation system for wind-turbine towers that cuts the amount of concrete used by 75 percent – reducing carbon-dioxide emissions, shortening wind-farm construction times, and lowering the overall cost of wind energy.

RUTE Foundation Systems and a research team at Portland State University received early-stage investment support from Oregon Best to commercialize the new technology, which could speed wind-farm development and keep millions of pounds of carbon dioxide out of the atmosphere.

But Doug Krause, founder of RUTE Foundation Systems, said the project has progressed since news of the foundation system broke earlier this year.

"We're just leagues ahead there now," Krause said. "We have a qualified design that meets industry criteria, and we're building our demonstration project this year in eastern Oregon called Gorge Training Facility."

In June, RUTE was awarded a Small Business Innovation Research award from the National Science Foundation. The funding allows RUTE to optimize its hub component for commercialization. RUTE is now searching to hire a structural engineer for this task, combining the engineering fields of foundation design, post-tensioning systems, and structural finite element analysis.

CONCRETE PROCEDURES

Current wind-turbine tower installation involves pouring a large concrete footing at the base of each 300-foot tower. The footings are 9 feet thick and 60 feet in diameter and require 30 to 40 truckloads of

concrete – about 300 cubic yards. Each footing weighs about 2 million pounds and is not removed from the soil when a turbine tower is decommissioned.

"We've developed a manufactured assembly of anchored grade beams that saves a lot of concrete, transportation costs, construction time, and carbon dioxide," Krause said. "Using this footing saves wind-farm developers time and money, is more environmentally friendly, and reduces the cost of bringing renewable energy to the world."

Construction of a single wind farm with up to 50 turbine towers takes many months to complete in ideal conditions. Weather and curing of the concrete used in the foundations

can affect wind-turbine delivery schedules, dragging out overall construction time and increasing costs.

"Our foundation system is delivered fully hardened, so there is very little risk as to if it will be installed, cured and ready when the turbine is delivered to the site," Krause said, who uses the analogy of a massive Douglas fir tree held in place by a root system that weighs much less than the total weight of the tree.

REDUCING CO2

Because the components in the RUTE system are made in a beam-manufacturing plant, the finished product is three times stronger than cast-in-place concrete. And using less concrete requires less cement,

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a material that is extremely energy-intensive to make and generates carbon dioxide during production. The RUTE system can save as much as 6 million pounds of carbon dioxide emissions for a single wind farm, according to Krause.

The company worked with Franz Rad, a Portland State University (PSU) professor of civil and environmental engineering, to design instrumentation and procedures to monitor structure response to the wind-tower loads at the demonstration project, Gorge Training Facility (GTF) in Sherman County, Oregon. The PSU work will provide critical third-party validation of the material properties and the structural design prior to commercialization.

"It is interesting and challenging for me and my grad students to look at replacing massive concrete footings with a new foundation system that has post-tensioned beams connected to a hub," Rad said. "Computer models show us the strength and stiffness of the foundation, and in the process, grad students learn about practical design, structural innovations, and developing specifications for a field monitoring program."

RUTE Foundation Systems is working with a technical team that includes Marvel Bridge Engineers in Denver and Schwager Davis.

Oregon Best supported the project with \$66,000 in early-stage investment funding. Ken Vaughn, director of commercialization programs at Oregon Best, said the project is an example of how a relatively mature clean technology can be improved through innovation, resulting in multiple benefits.

"This really shows how innovating an existing technology can further reduce the cost of renewable energy,

while also cutting greenhouse gas emissions," Vaughn said.

GORGE TRAINING FACILITY

The Gorge Training Facility (GTF) is being developed with a RUTE foundation and a 2.3-MW high NCF top-tier generator. GTF is a community wind-energy project. Public and education stakeholders will operate GTF as part of a regional career technology education and workforce training program, according to the RUTE Foundation Systems website.

GTF is expected to benefit the Columbia Gorge Community College's Renewable Energy Technology program and the Portland State University Maseeh College of Engineering. PSU has launched a research program to design the validation and instrumentation of the RUTE foundation. The project will generate enough supplemental revenue from electricity sales to support the regional career tech teaching staff.

This project is a first-of-its-kind energy education facility founded on job creation, high-school-level education, and career advancement. Similar to a "shop class" offered in schools of previous generations, the facility will support the needs of rural Oregon communities.

The site is in one of the nation's most fertile wind-farm locales, the Columbia Gorge which has 4,000

MW of operating wind turbines with another 10 GW permitted and under development. Rural students and aspiring energy workers are surrounded by wind, hydroelectric, and high-voltage infrastructure that defines the 2016 U.S. energy plan.

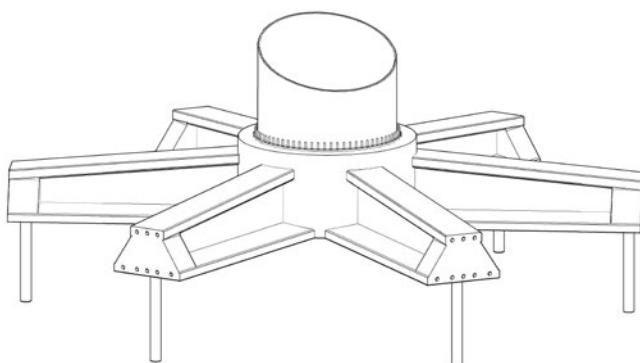
LOOKING FOR INVESTORS

"(GTF) is a real barn burner of a project in terms of the foundation we are building and the way we put that project together with all the different stakeholders. The piece of the puzzle that we're working on right now is bringing the investment parties together," Krause said. "We are definitely looking for investors. We have a pretty simple story to tell. The investment goes into our demonstration project which has a revenue stream from electricity, so it's a pretty safe investment to get a large return for an investment into our startup."

Oregon Best offers a wide range of support for clean-tech startups in Oregon and has more than 35 start-up companies listed as Oregon Best companies that are receiving help moving their technologies toward the marketplace. ↗

Source Oregon Best and RUTE Foundations

For more information, go to oregonbest.org and www.rutefoundations.com.



RUTE Foundation Systems

A schematic of RUTE Foundation Systems' new turbine foundation technology that will cut concrete by 75 percent.

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Giving Wind Direction

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CONVERSATION

David DiNunzio

Wind Application Engineer
Castrol



Please give us some background information on Castrol. How did it make a name for itself in the wind-energy industry?

Castrol® has more than 25 years of experience in the wind-energy market. Its lubricants were even used in the world's first wind-energy projects in the early 1980s. The company offers the wind market a dedicated full synthetic gear oil range alongside complementary lubricant products and associated services. These include specialist-testing facilities for screening new technologies and simulating operating conditions, as well as used oil analysis, such as Castrol LabCheck and Castrol Predict, to verify long-term characteristics

and customized lubricants training for wind-farm operators. Castrol's wind-turbine-specific lubricants are chosen as the "first-fill" lubricant for some of the world's major turbine manufacturers and are recommended by many leading bearing and gearbox suppliers globally. Castrol employs over 7,000 people in more than 140 countries who are working at the forefront of advanced lubricant technology.

What role does lubricant technology play when it comes to maintaining and operating today's wind turbines and maximizing their efficiency?

Lubricant technology can play a big role in the longevity and efficiency of wind-turbine mechanical components. Wind turbines use lower engineering design factors and operate in a wide range of environmental conditions, so we need to maximize the protection that lubricants can provide. As the wind-energy industry continues to expand, it brings with it the challenges of operating on a global scale from Central America, to the Midwest, and well up into the Arctic regions. In other countries, offshore wind turbines have demonstrated their own environmental and maintenance challenges. We continue to push the

limits of lubricant design and capability to enhance the reliability and efficiency of wind turbines everywhere. The evolution of lubricant technology enables us to meet these challenges and ultimately lower the cost of power generation.

Tell us about the products Castrol offers the wind-energy market.

Castrol has been a leader in the American wind-energy industry dating back to the 1980s and has learned a great deal during this time of market expansion. Using that experience, Castrol has developed lubricant options for all the turbine applications that can best match each individual customer's situation and conditions. We don't feel that one-size-fits-all is always the best approach. Our philosophy has always been to offer the best protection while maximizing the life of our lubricants. With this in mind, we have developed the unique capability to enhance product performance with uptower chemistry. Combined with our services, we strive to help our customers achieve the lowest total cost of ownership.

What types of services does Castrol offer the wind-energy industry?

As the industry matures, our ser-

“ Castrol’s wind-turbine-specific lubricants are chosen as the “first-fill” lubricant for some of the world’s major turbine manufacturers and are recommended by many leading bearing and gearbox suppliers globally.

vice offering continues to evolve to meet the needs of our customers. We provide support and oil analysis from installation through the life of the turbine. With intimate knowledge of the formulation and fluid/grease behavior, we can also provide recommendations for means to extend the life of our oils that are guaranteed to succeed. Castrol can provide troubleshooting assistance and inspection services both on the ground and uptower. This includes generating inspection reports with photos and borescope images. We also provide support during oil changes to ensure that the new lubricants are given the best chance to succeed. In addition, we can provide training support to upskill those who seek more knowledge on tribology.

How can industry members benefit from working with Castrol?

There are several advantages in working with Castrol here in the U.S. and abroad. We have relationships in all facets of the wind-energy industry from the OEMs and equipment suppliers to owners, service providers, and laboratories. We also are able to utilize Castrol’s global network of specialists to provide support for businesses that go beyond these U.S. borders. We have exciting projects taking place in many countries that can share best practices for the benefit of all.

Does Castrol offer any types of training for wind-energy professionals?

Castrol has a long history of providing training to their customers in every industry, and wind is no different. I highly encourage anyone who is interested to inquire about the training that we can supply related to the fundamentals of lubrication, wind turbine applications, and oil analysis, among others. We can then take a deeper dive into bearings, gears, and hydraulics for more advanced learning. Castrol has sponsored training classes at local community colleges, our locations across the country, and on many customer sites. These classes can provide a better understanding of the surface interaction and how lubricants can help drive the reliability needed for this industry. It also shows how storage and handling can impact lubricant longevity and the routine testing that takes place. We would be glad to customize the materials to fit the scope and size of what you might be seeking.

What can the industry expect from Castrol in the future and going forward?

The industry is growing and evolving rapidly, and we want to continue developing technology to help further the wind-energy industry. We are working on the next generation of oils and greases that address specific issues in wind. So far, we are encouraged about what we have seen

in research and development. Look for some new products to come out soon. From the services side, we have added additional resources to the field. We’re excited to get more involved with our customers, especially from an oil analysis and recommendation perspective. Please don’t hesitate to reach out to your Castrol representative should you have any questions. ✎

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Preventing a Flame-up

Keep natural areas around wind turbines from becoming a fire hazard.

By Travis Dees



Fire prevention is a big land-management issue right now, especially after El Nino drenched most of the nation earlier this year. Weeds are at an all-time high, just as fire season kicks in. The past decade of droughts and catastrophic wildfires have left parched landscapes ill prepared. Project site assessments and maintenance practices should be carefully considered, especially given the large assets at stake on wind projects.

Dry vegetation can be an extreme fire hazard around wind turbines.

TIME FOR FIRE PREVENTION

A wet growing season was a blessing for farmers, ranchers, and watersheds; however, as the temperature warms up and new vegetation reaches maturity, it's not exactly a blessing for wind projects.

Dry vegetation is an extreme hazard, especially around

potential ignition sources. Owners and operators probably could expect more visits from fire departments this year thanks to El Nino, so make sure you're in compliance. Most municipalities or county fire departments have vegetation management regulations to remove or mow to a prescribed height before the start of the fire season. It is also important to know inspections are conducted throughout the dry season, and the property must be maintained in order to remain in compliance. Even if property owners abate their property early in the season, there is potential for re-growth.

For some power facilities, managing vegetation around equipment where an ignition source could occur is another best management practice (BMP). Around power transformers and inverters, vegetation should be removed from the ground in a radius of not less than 15 feet.

Clearing this radius will help prevent a fire from starting if the component has a major failure that causes sparks. Inside the substations, fenced parameters should be removed to bare ground or rock. Low-growing vegetation is often encouraged as a means of mitigating dust, but it should be mowed to a height of four inches since this is an effective way to minimize fire hazards while allowing for low ground.

Most fire requirements ask for large defensible spaces for the site, but codes vary by region. Clearing around power poles, turbines, transformer pads, and junction boxes is essential, along with the other obvious places on sites such as roads and buildings. A 10-foot radius around power poles will help prevent a fire from starting if there is any arching due to a failed component. Trees and other large brush should be cleared at least eight feet below a power line.

Maintaining roads also will help as a firebreak if a brush fire starts. Most roads in high-risk fire areas need a 20-foot distance on either side after a project has been constructed, allowing for access and acting as a firebreak.

Using parameter roads and fence lines as a firebreak is a site's best defense for the spread of fire whether the source is internal or external. Keeping the groundcover and fence line maintained may mean seasonal inspections and services to remove windblown vegetation that has accumulated. Vegetation in fence lines can become a tinderbox, so

this has to be cleared throughout the season, too.

Fire safety starts with mowing as one small spark from a mower or a mower's blade hitting a rock can result in a big fire. Given the high-dollar cost of the site owner's assets at stake on wind fields, hiring safety-conscious licensed professionals with proven track records is recommended, especially given the chemical and mechanical weed-abatement strategies used.

TUMBLEWEEDS

One of the biggest weed challenges often faced is contending with the dreaded tumbleweeds (also known as Russian Thistle). In the Antelope Valley alone last year, World Wind & Solar (WWS) removed more than 2,000 tons of tumbleweeds — that's 4 million pounds — from both solar and wind projects. Tumbleweeds can cause serious problems when they get caught in equipment. In order to prevent these problems, WWS tells clients it's better to be proactive than reactive.

Each tumbleweed can produce up to 200,000 seeds if it's not removed from the site, and it also contains oils that can be flammable. WWS will mow them while they're still green and physically remove them from the site. WWS also uses a chemical weed abatement program that requires careful planning and permitting.

There are other professionals to turn to. A great source for assistance in identifying potential fire risk is often times the county fire department. WWS recommends inviting them on site to help with a proper proactive approach.

REDUCING DAMAGE

Preparation now will reduce potential damage later. Set up operations and maintenance vendor agreements. Look at your policies: Do they follow best practices discussed here? Can your staff effectively manage the ongoing tasks that need to be performed? Between the wet-winter season, followed by what is expected to be a dry summer season, fires are a looming danger for projects with catastrophic consequences. Given all of these potential devastating effects from improper land management, wind pros should take steps to minimize damage and protect their projects. ↗

Online Heater Selection Tool Mounts and Dismounts Bearings

The new SKF online heater selection tool introduces an easy, convenient, and highly accessible resource to make the right pick among heater technologies for mounting or dismounting bearings and similar workpieces in an application.

Based on a bearing's designation or input of key parameters, the tool chooses the appropriate heater for a

job from SKF's comprehensive product range, including electric hot plate, induction heaters, and fixed induction heaters. Suitable heaters are grouped into "mounting" and "dismounting" families for quick reference.

The practice of hot mounting and hot dismounting of bearings and workpieces has served to reduce the risk



of damage to a bearing, shaft, or workpiece and help increase bearing service life and machine reliability. Ultimately, proper heater selection is critical for application success.

For standard bearings, the online heater selection tool requires only an SKF bearing designation to de-

termine the appropriate heater. In the case of other bearings or annular components, the online tool can select a suitable heater after users simply enter parameters defining the application and specifying the dimensions and weight of the bearing or workpiece.

Either way, the heater selection tool serves as a practical resource for use by customers or distributors anywhere and anytime. ↗

Source SKF

For more information,
go to www.mapro.skf.com.

New Tech for Inspections, Servicing, and Condition Monitoring

Romax InSight is launching two products to reduce cost and increase the effectiveness of wind turbine operations and maintenance (O&M).

EcoCMS is a new, low-cost condition monitoring system (CMS) for wind turbines. EcoCMS is aimed at making high performance CMS more affordable for wind farm owners, operators and OEMs. EcoCMS interfaces with Romax InSights' Fleet Monitor software — a hardware independent platform for condition monitoring

and reliability analysis. Romax uses its Fleet Monitor software to deliver condition-monitoring services to more than 3.5 GW of assets worldwide and offers technology transfer, training, and condition monitoring services to new ecoCMS users.

Romax's focus continues to be implementing a step change in the value of predictive maintenance for the wind industry.

"Romax has been working in the field of condition monitoring for many

years and in vibration engineering for decades, and we understand the requirements of CMS users very well," said Ashley Crowther, global vice president – InSight. "In fact, almost everyone we spoke to was frustrated at the high cost of CMS in the marketplace and need the improved ROI from more affordable CMS hardware."

Through a multi-year rollout, ecoCMS has built a strong track record of installation and fault detection on a large number of wind turbine

types including GE 1.5 MW, Vestas V80 2 MW, Siemens 2.3 MW, and many sub-megawatt machines around the globe. This track record has given Romax 100 percent confidence in the hardware and its damage detection capability, including class-leading performance for main bearing and planet bearing faults.

"Over the last few years, a lot has changed in the field of CMS and data acquisition," said John Coulgate, head of engineering development. "Firstly, the idea of putting 'intelligence' in the data acquisition box or in the sensors has proved to be unnecessary — this just drives up cost and the limitations on data storage and transmission are not relevant these days. Secondly, the explosion in embedded computing means that high performance systems can be deployed at very low cost, particularly compared to other condition-monitoring systems in the market — most systems today rely on an older and high-cost approach to architecture."

FIELD PRO

Field Pro is a new mobile/web application for wind-farm inspection and servicing to bring the wind industry further toward data-driven O&M. In the current O&M practice, there is a large volume of valuable data flowing in from the field including service and inspection reports, problem resolution, checklists, and photos. Much of this data is unused or lost, so the value is not leveraged, and so much money and time is wasted on administrative tasks for reporting and record keeping.

With the release of Field Pro, a step-change is possible for managing wind farm data by transitioning to mobile and cloud technology. Pen-and-paper-based checklists and work instructions become obsolete. Software organizes maintenance and inspection data automatically as soon as data is collected by smartphone. Synchronized devices and streamlined data transfer remove

the tedium and error from transferring data from borescopes, thermal cameras, and other O&M tools. Managers and technicians can access data in the cloud from anywhere in the world using the web portal.

"Although wind turbines are a progressive technology, O&M data management is largely stuck in the previous century," Crowther said. "Field engineers still use pen-and-paper checklists, and the quality of work depends entirely on an individual's experience; consistency is lacking. Adding this release to our InSight platform, we enable our customers to implement data-driven O&M practices, to maximize productivity and to increase quality."

"Field Pro makes it possible for all trained technicians to perform service and inspection to the highest standards, regardless of their expert experience," said Won Shin, Field Pro product manager. "With a mobile

device, the technician can follow detailed step-by-step guidance built by relevant experts while performing the required procedures. With just a few taps, a report is automatically generated and uploaded to the cloud. By having the entire team's reports on the cloud, a manager has real-time access to field data, facilitating instant communication between the office and the field team while they are still uptower. Managers can also visualize and track any issues for the entire wind farm using the Field Pro web portal with no extra effort, allowing decisions driven on accurate data from the field."

As a result of the two new technologies, Romax InSight expects to improve O&M quality and reduce O&M costs. ↗

Source Romax Technology

For more information, go to www.romaxtech.com.

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Adwen and LM Wind Power Create the Longest Blade in the World

Adwen and LM Wind Power have come together to build the longest turbine blade in the world.

The component is 88.4 meters long and has been specifically designed for Adwen's AD 8-180 wind-turbine model, with 8 MW nominal capacity and 180-meter rotor diameter. The first of these huge blades was manufactured at LM Wind Power's factory in Lunderskov, Denmark.

The engineering teams of both companies have been working together for months to design and integrate a blade that represents an important step forward in the race to lower the Levelized Cost of Energy (LCoE). With the largest rotor in the industry (180 meters), the AD 8-180 has the highest annual energy production of all wind turbines.

The LM 88.4 P blade has been designed with manufacturing and reliability in mind, benefiting from the know-how of LM Wind Power, which has developed large blades for offshore application for 25 years and resulting in a 925 MW installed base. LM Wind Power's track record combined with Adwen's powerful turbine, technology, and experience from operating 630 MW offshore wind farms have resulted in a state-of-the-art rotor integration.

The blade's 88.4-meter length is the best compromise between swept area, energy production, and weight as well as loads transferred to the wind turbine. This combination provides the optimum balance of plant costs and contributes to one of the most competitive LCoE in the industry. In addition, the blade design



Adwen

has been conceived with scalability in mind so Adwen's 8 MW platform can be developed.

"When you are building the largest wind turbine in the world, almost everything you do is an unprecedented challenge," said Adwen General Manager Luis Álvarez. "We are going where no one else has ever gone before, pushing all the known frontiers in the industry. Having developed and integrated together with LM Wind Power the first unit of the longest blade ever and being able to start testing is a key step forward in the development of our AD 8-180 and proves that Adwen is at the forefront of the industry."

"The LM 88.4 P blade is an extraordinary example of industrialized

The longest blade in the world is 88.4 meters.

innovation at record-breaking scale," said LM Wind Power CEO Marc de Jong. "It is based on innovation building blocks, rooted in 35 years of real-life experience, in the design, technology, and manufacturing of ultra-long, reliable blades. This blade is a strong proof point of the shared ambition of Adwen and LM Wind Power to bring forward best-in-class and proven rotor solutions for offshore application, increasing annual energy output through efficient and reliable technology." ↗

Source Adwen

For more information, go to www.adwenoffshore.com.

180 MW Armow Wind Facility Opens in Ontario

The Armow Wind Power Facility in Ontario held a grand opening hosted by Samsung Renewable Energy, Inc. and Pattern Energy Group LP. The 180-MW Armow Wind is expected to generate enough clean energy to power about 70,000 Ontario homes each year, based on average annual residential energy use in Ontario.

"The Municipality welcomes the Armow Wind Power Facility to our community," said Murray Clarke, chief administrative officer of the Municipality of Kincardine. "Throughout the process ... the developer has demonstrated a solid commitment to work with the municipality and maintain an open line of communication ... The Armow Wind project will contribute close to \$20 million of new tax, non-tax, and permit revenue directly to the Municipality of Kincardine. The community benefit component alone will equal close to \$13 million which will be used to support local projects and programming."

"We want to thank the landowners, other community members, and the municipality for their hard work and collaboration," said Mike Garland, CEO of pattern development. "Armow Wind was built by Ontario workers using Ontario-made wind-turbine components. It is having a strong positive impact on the community by generating millions of dollars in local lease payments and property taxes, updating the local airport, and improving the community of Kincardine through our community benefits program."

"Armow Wind is operational and not only producing renewable energy but also generating economic growth for the Kincardine community," said Steve Cho, president of Samsung Renewable Energy Inc. "We are pleased to have delivered on our commitment to the Green Energy Investment Agreement by producing hundreds of jobs in construction and manufacturing. Armow is the fourth wind project to be completed under the GEIA, and Samsung Renewable Energy is pleased to be a part of the Kincardine community."

Using Ontario-made wind-turbine components, Armow Wind provided jobs for more than 350 Ontario workers during peak construction activity with an average of 200 workers on-site throughout the construction process. Towers for the 91 Siemens 2.3 MW wind turbines were made in Windsor, and the 273 blades were manufactured in Tillsonburg by more than 750 Ontario workers.

"Siemens is proud to be a key supplier for our partners on another successful wind project in Ontario," said Da-

vid Hickey, vice president of Wind Power & Renewables for Siemens Canada Limited. "With locally produced steel, towers, and blades, Armow Wind is another great example of the positive economic impact the wind-power industry has on the Province of Ontario and is a progressive step towards environmental sustainability."

In addition to producing clean power, Armow Wind is bringing strong economic benefits to the Kincardine community, including more than \$75 million over 20 years in property taxes, landowner lease royalties, and community benefits.

Armow Wind committed \$13.6 million to the Municipality of Kincardine as part of a long-term Community Benefit Program, which supports education and other initiatives, including a contribution of \$1 million to the Kincardine Airport to improve local operations.

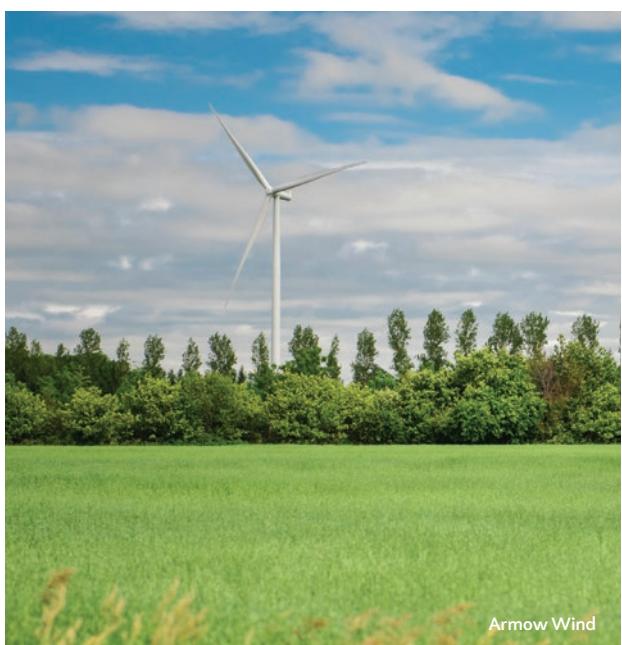
The Armow Wind power facility operates under a 20-year power-purchase agreement with the Independent Electricity System Operator.

Samsung C&T and its partners are making a \$5 billion private-sector investment in Ontario to create clean, renewable energy for generations to come.

Samsung signed a commercial agreement with the Government of Ontario that will result in 1,369 MW of installed renewable energy capacity in Ontario. ↗

Source Pattern Development

For more information
go to www.patterndev.com.



A wind turbine at the 180 MW Armow Wind Facility.

Armow Wind

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Siemens to Supply Norway Wind Turbines



Siemens has received an order to supply, install, and commission 50 onshore wind turbines in Norway. Project developers are Zephyr AS and Norsk Vind Energi AS. The wind turbines, each with a capacity of 3.2 MW and a rotor diameter of 113 meters, will be built in Rogaland, south of Stavanger in Norway.

The wind power plant, Tellenes, will produce the clean energy equivalent to the annual consumption of 30,000 Norwegian households.

Under an agreement, Google will use the renewable energy produced by the wind turbines to power data centers in Europe. Siemens also will be responsible for operating and servicing the wind turbines under a long-term agreement.

"Technology companies such as Google are increasingly covering their rising energy demands with clean wind power," said Thomas Richterich, CEO of Onshore of Siemens Wind Power and Renewables Division. "We are proud to be part of

this development with our direct-drive technology. Tellenes will also be one of the largest onshore wind projects in Norway."

Siemens will deliver its direct drive turbine SWT- 3.2-113 for the Tellenes project. Construction was planned for July, and the project is expected to be fully operational in late 2017.

The wind project will provide Google's European data centers with renewable energy for 12 years. This cross-border arrangement is possible due to Europe's increasingly integrated energy market. The Scandinavian Nord Pool market allows Google to buy renewable energy with a Guarantee of Origin certified in Norway and consume an equivalent amount of power elsewhere in Europe. ↗

Source Siemens

For more information,
go to: www.seimens.com/wind.

CONSTRUCTION

BOP/EPC • Project Status • Siting • Equipment • Project Due Diligence • Services

GE Renewable Energy's First Offshore Wind-Turbine Nacelles Headed to the U.S.

The GE Renewable Energy offshore wind-turbine plant in Saint-Nazaire, France, is completing the manufacturing of its first commercial series of Haliade Offshore wind turbine nacelles. The five 370-ton nacelles were scheduled to begin their voyage to the United States in July. They will equip the Block Island Wind Farm, the first of its kind in the U.S.

The Block Island project is off the coast of Block Island, Rhode Island. The Haliade turbines, ordered by Deepwater Wind, will be installed starting in August. With a total capacity of 30 MW, the Block Island Wind Farm will produce 125,000 MW/h of electricity per year, enough to supply electric power to 17,000 households. It will be connected to the grid by the end of 2016.

"This marks a milestone for the company, and we are proud to contribute to the Block Island project, the first offshore wind farm in the United States," said Anders Soe-Jensen, CEO of GE Renewable Energy's Offshore Wind unit. "This demonstrates our readiness to respond to expanding international demand. We are well-positioned to become a major player in offshore wind energy, and to lead in the energy transition across the world."

"We're proud that America's first offshore wind farm will feature, in GE's Haliade turbine, some of the world's most innovative offshore wind technology," said Deepwater Wind CEO Jeffrey Grybowski.

The industrial site at Saint-Nazaire was designed to produce up to 100 turbines per year.

The plant also will be the assembly site for 66 wind turbines intended for the Merkur wind farm in Germany,



followed by 238 turbines slated to equip the three French wind farms in Saint-Nazaire, Courseulles-sur-Mer and Fécamp installed by EDF Energies Nouvelles.

The Haliade turbine specifically was designed for a marine environment. Due to its 150-meter blades, its output is 15 percent higher than the offshore turbines of the same generation. Producing 6 MW of power, it is capable of supplying the equivalent of 5,000 households per year, with annual carbon dioxide savings of more than 23,000 tons. At a total height of more than 550 feet, the Haliade is almost twice as tall as the Statue of Liberty. Its blade, which measures almost 500 feet in diameter, is comparable to twice

A Haliade nacelle outside GE Renewable Energy's new factory in Saint-Nazaire, France.

the wingspan of an Airbus. Its outsized blades cover a surface area of 58,595 square feet, three times the area of a football field.

GE Renewable Energy is a \$9 billion start-up within GE and brings together one of the broadest and deepest portfolios in the renewable energy industry. The company has the largest renewable energy installed base with 370 GW and is present in more than 40 countries. ↗

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CROSSWINDS

Wind Energy a Key to ‘Tomorrowland’

By Kenneth Carter

An interesting development in the wind-energy industry is reminiscent in a way to a recent movie from Disney — “Tomorrowland.”

In the flick, a girl finds a button that unlocks a door to another world. That world is an alternate reality existing on a different plane from ours where scientific developments that seemed like science fiction 50 years ago actually exist.

Among those achievements are ways to make the world the clean, non-polluted utopia that so many works of fiction — “Star Trek” for another example — say the world could be if we only worked together to make it happen.

So what does that have to do with wind?

Turns out, a project in Wyoming has turned a closed coalmine into wind farms.

The Dave Johnston Coal Mine in Converse County once produced more than 104 million tons of coal in its four decades of operation. But it shut down more than 15 years ago.

But Wyoming took those lemons and well, you know the rest of that cliché.

Officials restored the land to its natural state and transformed the once prolific coalmine into wind farms.

Now, that reclaimed land boasts three wind farms totaling 158 turbines that generate 237 MW of electricity, officials say.

It's interesting that a renewable source of energy is responsible for actually “renewing” land for that very source of electricity.

How this wind development mirrors “Tomorrowland” was that it's like the wind farms co-exist on a different plane from our own — where renewable energy is the norm, and fossil-fuel energy is a distant memory.

For many areas, “Tomorrowland” is no longer “tomorrow.” Wind-energy investors are constantly looking for new and innovative ways to add more energy to electric grids using wind.

In Wyoming, it's already happening. That state is the biggest producer of coal in the country, and yet, it has been able to transport a mine from one reality into another. Fiction has become fact.

The American Wind Energy Association says there's enough wind in Wyoming to power the entire country.

Hyperbole? Maybe. Maybe not. But there are a lot of wind opportunities waiting in Wyoming, and many investors are certainly turning to the Equality State to see which way the wind blows.

And although coal is not exactly on its way out anytime soon, new federal regulations are making it harder for the industry to keep growing.

President Barack Obama's Clean Power Plan hits coal hard, and the Department of the Interior no longer allows coal mining on public land. That edict also hits Wyoming's coal producers hard as well — a majority of its mines are on federal property.

So to be able to take those existing areas and make them havens for renewable energy is an idea that looks good to investors and Wyoming officials alike.

The hopes of transforming other areas dependent on coal into sources of renewable energy are still works in progress, but the wheels are turning from Montana to Appalachia, and that's a good thing.

Wind energy can create 30 percent more jobs than a coal plant, according to Windustry.

That forward thinking has pushed wind energy to many areas that seemed like only an interesting dream not too long ago.

As a result, wind farms have spread across many landscapes over the last 15 years, and not just on top of refurbished coalmines.

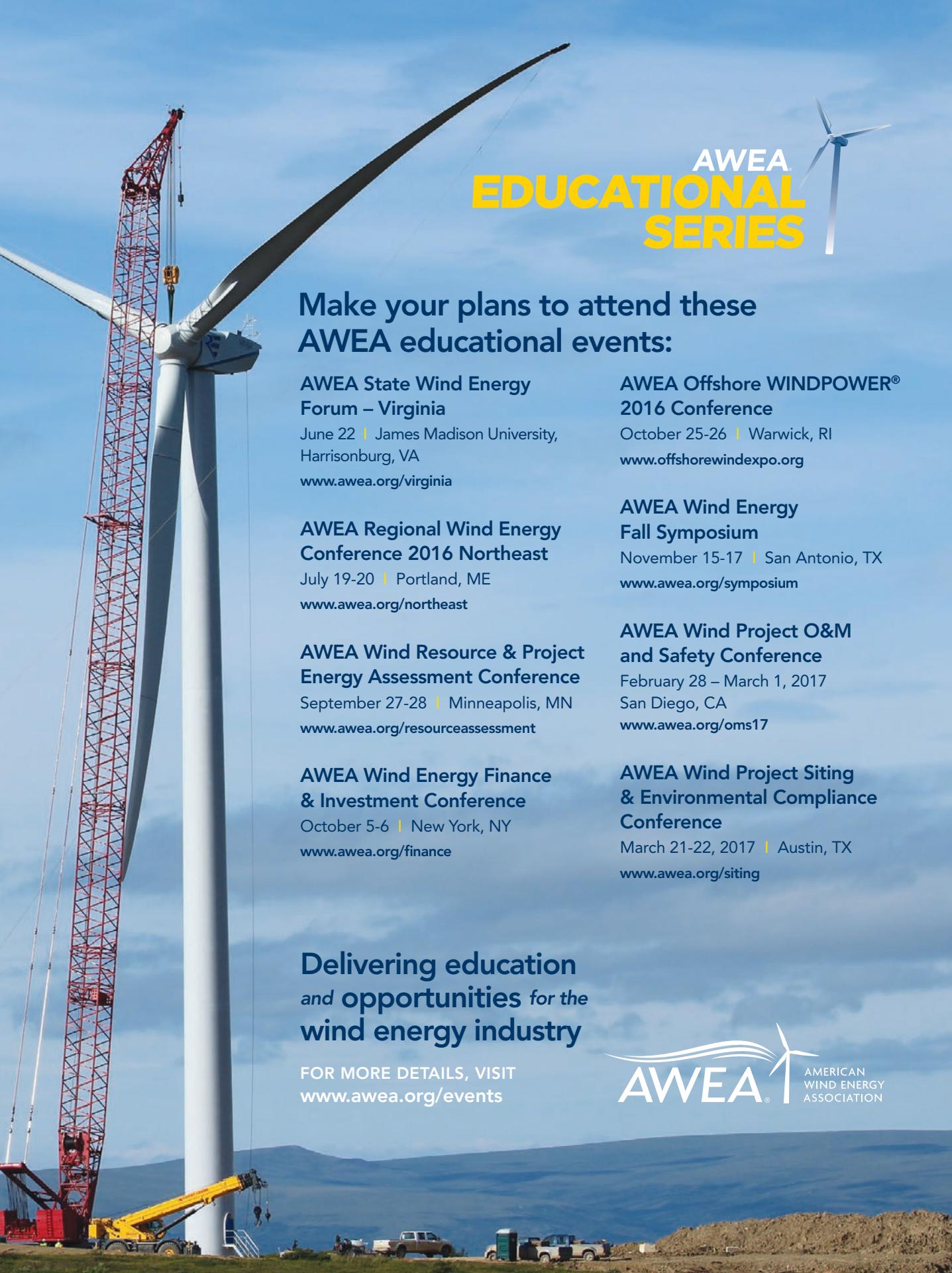
Silhouetted wind turbines against rolling skies of red, purple and orange are fast becoming common sights when traveling the country.

Not very long ago, those beautiful backdrops were littered with industrial smoke stacks that spewed thick, black clouds into the atmosphere — polluting our air with carbon that has pushed our planet to its limits.

Clean-energy initiatives have helped push back, and it's working. And investors also have discovered that helping the planet helps the bottom line, too.

Has the world become “Tomorrowland” yet? Sadly, no. But the wind-energy industry is working hard to transport us into that alternate — and better — reality.

And that's an initiative that can, sometime soon, transform the fictional “Tomorrowland” into a real “today.” ↗



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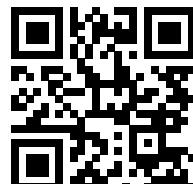
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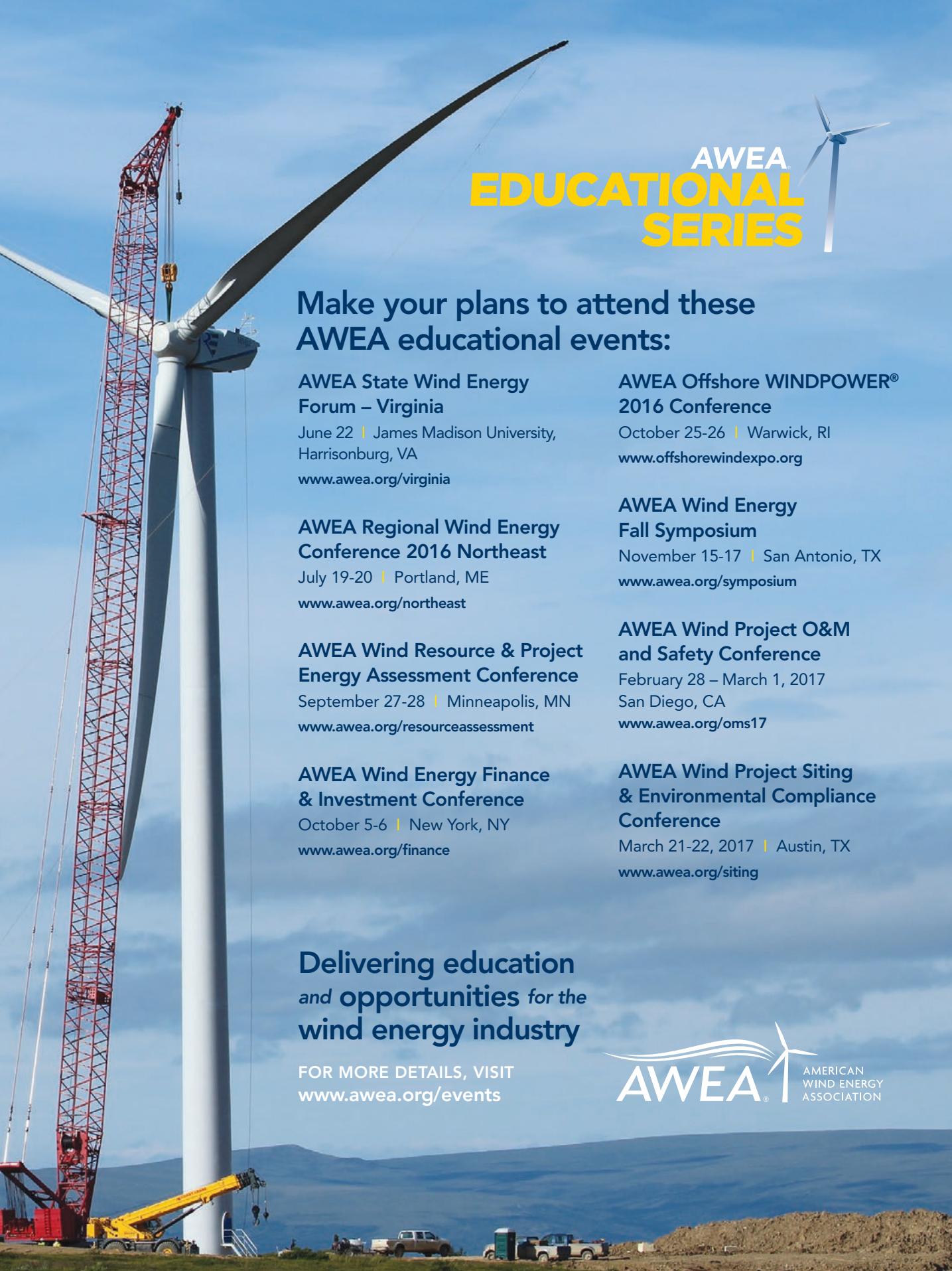
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Giving Wind Direction

WIND SYSTEMS

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MARKET DIRECTORY

AUGUST 2016



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A Strong Wind Blows Deep
in the Heart of Texas

Cover Photo: Courtesy of iStock

EDITOR'S DESK

AUGUST 2016

Since the extension of the Production Tax Credit, the future of the wind-energy industry has never looked stronger.

This clean, renewable source of energy is making strides like never before. That's a good thing — both for the environment and investors.

We at *Wind Systems* want to help by making sure those involved with wind energy are ready to take advantage of the opportunities out there.

Wind Systems has reached out to many experts in the industry, and they have provided in-depth information about the current state of wind power in the U.S. and where it is headed.

In our second Market Outlook edition, we take a look at several areas of the country that already are pushing the boundaries of an energy alternative that is growing exponentially.

In the Midwest, Iowa Gov. Terry Branstad is proud of what his state has done for the wind industry, and he is happy to share that knowledge in one of our State Spotlights.

In his article, he boasts that Iowa gets more than 30 percent of its energy needs with wind. And that's just the beginning of what Iowa has been doing in the industry.

The wind is also quite prolific in Texas, where the Lone Star State creates more electricity from wind than any other state — and most other countries. Texas' leadership in the wind industry makes it ideal for the focus of our second State Spotlight.

Experts say Texas' diverse geography makes it and wind a perfect fit, and that's good news for companies looking to wind for their energy needs.

And wind prospects are good not just in Texas and Iowa, but also all over.

The American Wind Energy Association's John Hensley says that wind power in the U.S. could be supplying 20 percent of all electricity in the country in less than 15 years. As far as new energy resources are concerned, wind is preferred by most.

And as costs continue to fall, using wind becomes all the more lucrative.

In addition to the PTC extension, the IRS also has some good news for wind developers. Writer Lisa Cohn hits on several points on what the PTC extension and the IRS decision could mean for current and future wind developments.

Economist Angelos Angelou takes a look at how the wind industry is still managing to make strides despite the economic and political uncertainty that surrounds more traditional energy makers.

Those are just a few highlights of the information that is part of *Wind Systems'* annual Market Outlook.

I hope you find it as informative and interesting to read as I did. I also hope you find the information as a positive affirmation that the future of wind is still a powerful force in the renewable energy arena.



Kenneth Carter, managing editor

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A handwritten signature in black ink, appearing to read "Kenneth Carter".

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Angelos Angelou is the founder and principal executive officer of Angelou Economics, bringing nearly 30 years of experience in economic development and site selection. He is responsible for strategy development and is heading up the firm's site selection

practice. Having spent 11 years with the Greater Austin Chamber of Commerce as vice president of economic development, Angelos brings a practitioner's approach to AE's economic development team. During his time at the chamber, Angelos was responsible for the recruitment of 400 technology companies and about 70,000 employees. Angelos holds an M.A. in Economics cum laude from St. Mary's University in San Antonio and a B.A. in Economics from the University of Texas at San Antonio.

Lisa Cohn has worked as a writer for more than 20 years, focusing on energy and the environment. She has received 10 writing awards from the Pacific Northwest Writers Association, Willamette Writers, Associated Oregon Industries, Parenting Publications of America and other associations. She began her writing career as an energy and environment reporter for The Cape Cod Times.



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A Win for Wind Power

Wind industry stays afloat amidst economic and political uncertainty.

By Angelos G. Angelou



The winds of fortune are shifting rapidly for the energy sector. The rise of hydraulic fracturing and the ongoing OPEC-driven supply glut have pushed fossil fuel prices well below historic norms. While there is evidence that supply is once again starting to constrict, the continued abundance of dirty but cheap fuels, particularly natural gas, has called the economic viability of renewable energy into question. Conversely, the signing of the Paris climate accord and the EPA's renewed efforts to regulate carbon emissions mean the political and social climate for renewables has never been better. Throw in the unprecedented interest and investment in new energy technologies, and the prognosis for the industry quickly becomes chaotic.

But it is not a chaos without opportunities for wind power.

For existing supply chains, conditions remain largely favorable. It's true that a strengthening dollar and a flagging global economy have continued to pressure the already anemic U.S. manufacturing industry. With that said, energy manufacturers seem largely immune to these woes. While overall, the industry has shed 13 percent of its workforce over the past decade, employment within the turbine-manufacturing subsector, which of course includes wind power, actually has grown by more than 40 percent. Likewise, it is one of the few manufacturing niches to enjoy a multibillion-dollar export

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“EMPLOYMENT WITHIN THE TURBINE-MANUFACTURING SUBSECTOR, WHICH OF COURSE INCLUDES WIND POWER, ACTUALLY HAS GROWN BY MORE THAN 40 PERCENT.

surplus over the past several years.

The regional players benefiting from these trends remain the usual suspects: Texas, the Midwest, and parts of the South. These clusters are well-positioned to dominate this burgeoning industry, and they are home to a robust manufacturing heritage with easy access to both strong logistical hubs and prominent wind-energy markets. Moreover, all signs point to a growing domestic demand that will keep suppliers busy for the foreseeable future.

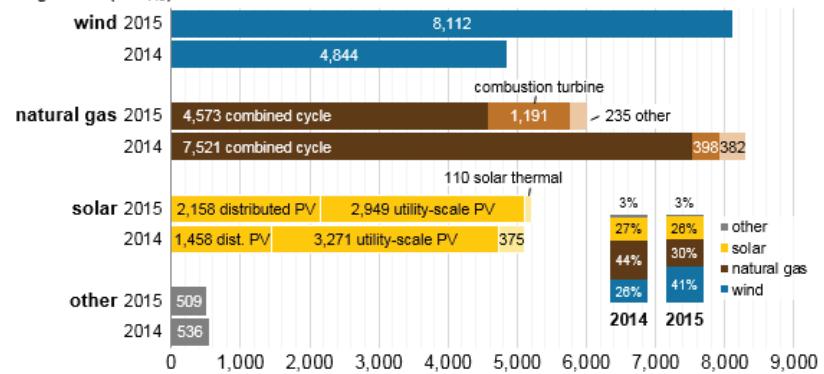
Iowa took the lead in this wind-energy charge with a recent announcement from MidAmerican Energy promising to add 1,000 new wind turbines to its grid. The additional 2,000 MW of energy provided will boost the state's renewable portfolio to 85 percent, matching last year's pledges from Vermont and Hawaii for near-carbonless electricity production by 2050, and those announcements were the cherry atop what was already a boon

year for wind power. According to the Energy Information Administration, some 8,112 MW of wind capacity were added in 2015. Accounting for 41 percent of total new capacity, wind power was the leader in additional renewable generation, and indeed additional generation in general, for the year.

All of this indicates that America's wind industry mostly has been unaffected by the strife facing its fossil-fuel counterparts. In fact, it may be benefiting from that strife. Faced with the economic and political uncertainty surrounding traditional energy sources, many utilities and state governments seem to be opting for less volatile renewables, wind power included. But some of the most exciting developments for the industry aren't political or economic, or even related directly to wind. They're happening in the realm of batteries.

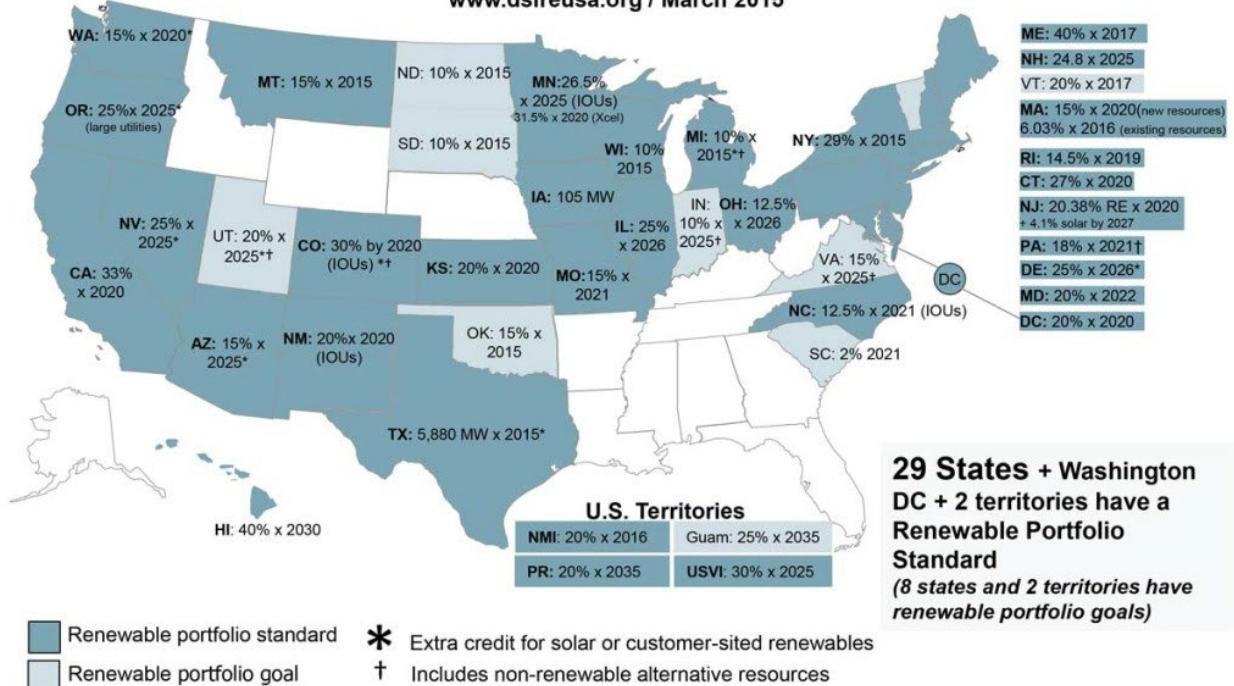
Tesla's planned Gigafactory, its Powerwall prototypes, and the general renaissance of battery technol-

U.S. electric generation capacity additions, 2015 vs. 2014 megawatts (MW_{AC})



Renewable Portfolio Standard Policies

www.dsireusa.org / March 2015



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(8 states and 2 territories have renewable portfolio goals)

ogy could shape the future of the green-energy sector. If they prove economically feasible, such innovations would unshackle renewable energy from the constraints of weather and sunlight and encourage investment in distributed generation. It has traditionally been solar that is viewed as the go-to resource for small-scale commercial and residential energy projects. However, recent improvements in vertical-turbine technology have created new opportunities for the so-called “small wind,” particularly in the Northeast, Great Lakes, and Pacific Northwest regions where sunlight is not plentiful.

That's not to say wind technology, big or small, cannot make yet even greater strides in improving reliance and efficiency. It should therefore come as good news to pioneering wind-energy researchers that President Barack Obama signed a permanent extension of the R&D tax credit in January. Similarly, state-level R&D credits such as those found in Minnesota and Louisiana can go a long way in offsetting the costs faced by entrepreneurs entering the market. Combined with the numerous wind-energy rebates and subsidies cat-

aloged by the Department of Energy's DSIRE database, the conditions are set for the continued evolution of wind designs.

But just as public policy can be the great benefactor of wind power, it also can be a hurdle. In Texas, for instance, the last legislative session saw efforts to roll back portions of the state's renewable energy portfolio. As the political battles over the country's energy future continue to heat up, it's likely similar initiatives will become more frequent at both the state and national level.

The lesson of the ongoing policy debate is clear: Wind producers cannot rely on public support to be relevant, but must rather remain successful in their own right. The good news is both manufacturing and research operations within the industry show great promise. The future of America's energy sector is uncertain, but it's also diverse. More importantly, there is a clearly defined role to be played by wind power. As long as the industry doesn't become complacent and fail to adapt, there's no reason wind energy cannot remain profitable for decades to come. ↗





Breathing New Life into Wind

PTC extension gives wind-industry projects a chance to really take off.

By Lisa Cohn

The five-year extension of the Production Tax Credit has breathed new life into the wind industry, and as a result, new wind-plant additions are expected to peak at 9 GW in 2018.

The Production Tax Credit and Investment Tax Credit were extended for five years with a gradual ramp-down of benefits for each year.

"The extension rejuvenated the industry," said Mike Lorusso, managing director and group head of CIT Energy. "Deals that were on the verge of getting done continued along and are now going into construction. Further down the road, it jump-started other deals and gave the industry a nice lifeline."

The PTC extension is significant, said Bruce Bailey, CEO of AWS Truepower, a renewable energy consultant.

"At last, there is certainty about federal-tax incentives over a reasonably long period of time," Bailey said. "We are seeing clients reactivate their pipeline of greenfield projects, and there are more banks and investors either getting into the game or upping their level of activity. Generally speaking, I'd have to say that there is much more confidence about wind's long-term future."

Financing sources are expected to increase as a result of the extension, said Nicholas Knapp, managing director for CohnReznick Capital Markets Securities, LLC.

"This will allow for a higher volume of projects to be completed in a shorter time frame and under

a more competitive cost of capital," Knapp said.

CONSTRUCTION BREATHING ROOM

More good news for wind developers comes from the IRS, which said developers have up to four years to complete construction under the extension, which gives them some breathing room and allows for a less frenetic dive toward com-

pletion over the next four years.

"Developers are being exempt from the continuous construction rule," a rule that said in the past that developers only could get the Production Tax Credit if they refrained from taking breaks on a project, said Bruce Hamilton, energy director for Navigant. "This leads to less of a rush."

If developers begin a project in 2016, they have until 2020 to complete it.

Hamilton said this will help boost the fledgling offshore wind industry, which requires up to two- to three-times longer to complete a project.

In the past, developers had to complete projects in two years.

"The five-year extension of the PTC and the four-year IRS guidance certainly have a very positive impact — not only for opportunities next year, but opportunities for the future," said Jacob Andersen, CEO for Onshore Americas, Siemens Wind Power and Renewables Division. "Now we can engage in long-term planning and continue our investments in new technology to get cost down."

Siemens now has an opportunity to help customers significantly boost onshore wind power capacity in the U.S. over the next several years.

"We expect that the coming years will be strong for onshore wind installations in the U.S., and we also see positive signs in respect to offshore wind development," Andersen said. "There is, however, still work to be done on the regulatory environment for offshore wind where we need to find a solution to shorten the currently too long permitting time for development."

As a result of the PTC expansion, the wind industry should experience high levels of market penetration in 2018.

In 2018, the wind industry's share of the total market is expected to be about 70 percent of added capacity, but will drop down to about 20 percent in 2021.

MANUFACTURING AND JOBS INCREASE

Increases in the number of wind turbines online have boosted manufacturing and wind-related jobs. At the end of 2015, there were more than 500 wind-related manufacturing facilities across 43 states, producing products that included major components such as blades, nacelles, and towers, all the

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The advertisement features a map of the Big Elk Industrial Park showing various plots of land labeled with acreage and status (e.g., SOLD). It also includes a photo of a bronze elk statue standing in a grassy field, a logo for the City of Elk City, and a small map of Oklahoma with Elk City highlighted.

way down to smaller components such as bearings, fasteners, and sensors, according to the DOE.

The wind sector now employs more than 70,000 workers and is expected to increase those numbers by an additional 10,000 this year.

Corporations seeking to embrace sustainability are becoming a larger segment of the market. About 37 percent of the MW contracted through power-purchase agreements during the first quarter of 2016 were from corporations and other “emerging” customers, including the Department of Defense, according to the American Wind Energy Association.

Along with a strong short-term outlook comes expected growth in O&M. However, with many new players vying for the business, the O&M market has become fragmented, said Stephen Curtis, director of renewable energy sales for SKF USA.

“A lot more of these independent service providers are getting into the market and doing repairs that involve our products — generators and gearboxes, for example,” Curtis said. “That market tends to be fragmented. There are a lot of players, and the size of the market isn’t clear.”

The size of the market is a moving target, he added.

Hamilton said the major challenges to ensuring the competitiveness of the industry are competition from solar power and reduced demand.

“The price of wind is going down significantly, but solar is going down more significantly,” Hamilton said.

Other obstacles include finding good wind-power sites, given that many of the best sites are taken, and less demand from utilities that have met their Renewable Portfolio Standard requirements, according to Lorusso.

As a result, the major manufacturing gains are taking place internationally, Lorusso said.

In spite of such obstacles, this year got off to a great start. The first quarter

of 2016 was the best first quarter since 2012, with 520 MW of wind power added, according to AWEA.

NEARLY 9.4 GW IN CONSTRUCTION IN 2015

About 9.4 GW were in construction as of year-end 2015, according to Navigant. About 8.6 GW were installed in 2015.

“A total of more than 15,200 MW of wind capacity were reported as under construction or in advanced stages of development during the first quarter of 2016 with over 3,500 MW of total new announcements,” according to AWEA’s first-quarter 2016 market report.

Project developers reported more than 10,100 MW of construction activity across 81 projects in 25 states, including more than 2,000 MW of new construction announcements. Texas was home to the majority of construction activity, with nearly 5,500 MW reported. AWEA said that about 5,100

MW of projects were in advanced stages of development.

Navigant predicts 8.2 GW will be installed in 2016, and 7.2 GW will be installed in 2017 in the U.S. And Texas is expected to lead installations.

GE Renewable Energy led the wind-turbine manufacturing sector in 2015, capturing 40 percent of the cumulative market share of installed turbines. Vestas captured 33 percent, and Siemens captured 14 percent, according to DOE.

The U.S. market is expected to continue to grow through 2018 due to PTC incentives, and wind is expected to provide about 50 percent of U.S. generation additions, ranging from 25 percent to 70 percent during that time. Interestingly, 65 percent of the MW under construction is in states with no RPS, Navigant said.

Meanwhile, offshore wind projects are increasing. More than 20 U.S. offshore wind projects are in development, with a combined capacity of about 16

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GW. Seven of those projects, or about 700 MW, are in advanced stages of development or construction, according to Navigant.

O&M GROWTH AND ADVANCES

With the growth associated with the PTC extension in both onshore and offshore wind projects comes a robust O&M market and demand for new O&M services — specifically, systems that monitor the status of equipment in real-time and predict wind-turbine problems.

"A recent survey of ours revealed that 86 percent of respondents fully believe service revenue to eclipse product revenue in the next two years," said Athani Krishnaprasad, co-founder of ServiceMax. "That means companies won't be making the bulk of their revenue on selling their 'thing,' but rather servicing it."

EDF Renewable Energy, which has more than 10.7 GW of O&M under contract, has seen a 400-percent growth rate since 2007. By the end of 2015, the company's growth had doubled, said Dalen Copeland, vice president of business development for EDF Renewable Energy.

"We are looking around to try to figure out how to provide the highest value services to customers," she said.

The company wants to provide a renewable assets intelligence platform that provides real-time transparency on asset performance and allows the company to help improve the performance of plants by zeroing in on what's causing downtime.

"The wind industry is wrestling with big data," Copeland said. "Wind plants throw off a lot of data. Depending on what data systems you have installed, you need to make sure you're getting good data quality and can turn it into something useful."

Along with the interest in using big data comes a need for research and development in establishing common standards that would allow industry

members to share information about wind-turbine "health monitoring" efforts, said Patrick Lemieux, a professor of mechanical engineering at California Polytechnic State University.

"Right now, the big utility machine manufacturers, about 10 worldwide, will each develop their system for themselves in a priority manner," Lemieux said. "You can't call GE and have them offer you their turbine-health-monitoring machine. This is their own intellectual property, and they are guarding the science behind it."

Lemieux said his R&D focuses on helping provide an "open literature-based environment" for such systems so the research is available to the entire industry. This would help improve the competitiveness of the industry.

R & D CONTINUES TO FOCUS ON BIGGER WIND TURBINES

The focus of R&D efforts continues to be larger towers and longer blades expected to harness stronger and more consistent winds. This is expected to provide for wind energy harvested in an additional 700,000 square miles, or about one-fifth of the land area in the U.S., according to the DOE.

These R&D efforts also are expected to boost manufacturing close to wind-power sites in an effort to keep transportation costs low. Advanced manufacturing techniques for taller towers — modular assembly or on-site tower production — is seen as a new opportunity for the industry and its suppliers.

In addition, the DOE is funding an effort that will apply 3-D printing to the manufacturing of wind-turbine blade molds. The project aims to improve wind-facility efficiency and cut wind-turbine manufacturing costs.

Simplifying how turbine-blade molds are made is the initial focus.

Right now, a 'plug' is made and it's used to make a mold that's later used to make fiberglass blades. 3-D printing applied directly to the mold process can eliminate the plug, reducing costs and the manufacturing time, according to the DOE website.

In addition, the DOE is working on the Atmosphere to Electrons Initiative, which aims to coordinate and optimize advances in wind-plant aerodynamics, plant performance, financial risk assessment, atmospheric science, and next-generation wind-plant technology.

"The exciting stuff is getting to bigger turbines, and that's been a continuing march," said George Favaloro, managing director in PwC's Sustainable Business Solutions practice. "The Southeast U.S. hasn't seen much wind development because wind at the ground levels doesn't have the speed. But if you get up higher, in the 170-meter range, there's more airflow, so it changes the game."

While the push for bigger turbines has huge potential, it introduces other problems, he said. Transporting the blades can be difficult.

Like the DOE, Favaloro said he expects to see more components made on-site.

Overall, the industry is thrilled with the extension of the PTC and ITC and the opportunities the extension affords. "Wind financiers have been dreaming about a long-term PTC extension for nearly two decades," Knapp said. "A long-term view allows the existing tax equity investors and lenders to develop multi-year allocation of capital for budgeting purposes. It allows new tax-equity sources that were otherwise on the fence due to unreliable PTC policy to now take action and secure final approval to officially enter the market." ↗

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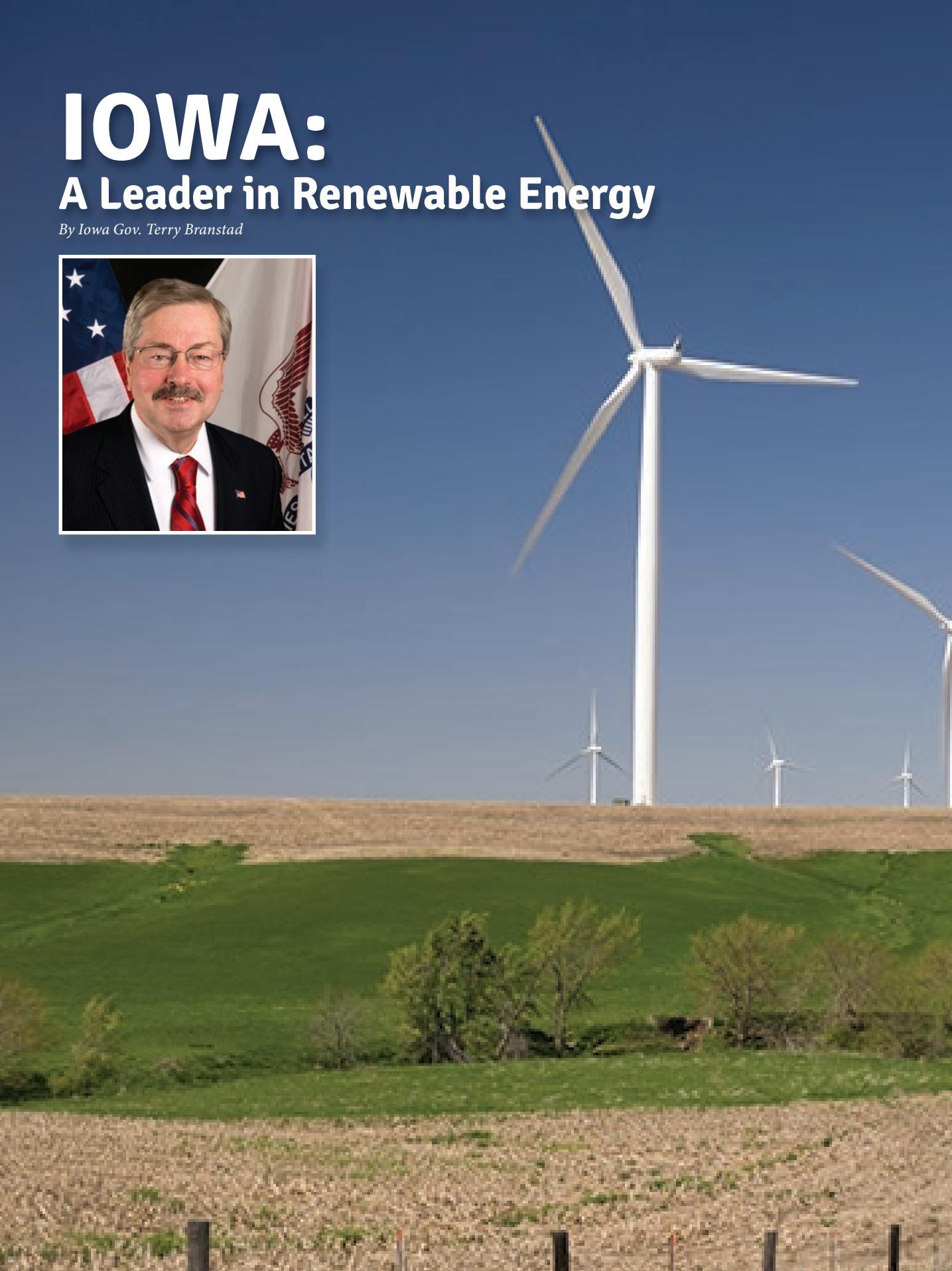
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IOWA: A Leader in Renewable Energy

By Iowa Gov. Terry Branstad





When you imagine a future for wind energy nationwide, you don't have to look farther than the state of Iowa as a shining example of what could be.

Iowa is already the national leader in wind-power generation, and we have a goal — and a plan to achieve it — to be the first state in the nation to meet 40 percent of our electricity needs from wind power by 2020.

In April, MidAmerican Energy Company, our state's largest energy provider, announced plans to invest \$3.6 billion in additional wind capacity, putting our state on pace to reach that 40 percent goal.

Wind currently generates more than 30 percent of Iowa's power, the largest share of any state. Spinning wind turbines dot our rolling fields, each one generating clean energy and providing income for farmers, revenue for local governments, and jobs for Iowa families.

Iowa's central location, positive business climate, and transportation infrastructure have made the state an attractive location for global turbine manufacturers. Today, almost the entire turbine life cycle, from manufacture to assembly to construction, can occur within Iowa's borders.

The people of Iowa have also been instrumental in the success of the industry. The entrepreneurship and ingenuity of our state's small business owners have had an immeasurably positive effect on wind energy as a whole. As wind-turbine manufacturing has scaled, Iowa companies have been pioneers. They have overcome obstacles and piloted solutions later put into practice globally.

An example of such a company is KPI Concepts in Burlington, in southeastern Iowa on the Mississippi River. KPI Concepts manufactures wooden components for turbine blades. Its founder, Craig Upton, manufactured shelving for retail stores, when in 2008 an executive from Siemens contacted him and asked if he also could make blade components. Today, Craig manufactures components for both Sie-

mens and TPI Composites, making use of machines that he designed.

Iowa's public universities and their excellent engineering colleges have also embraced the state's leadership in wind energy, undertaking academic research to further the industry and developing specialized programs to educate the next generation of wind-energy engineers and policy makers. The state's extensive network of community colleges has taken on the challenge of developing the industry's on-the-ground workforce and has created specialized programs that are educating technicians who install, maintain, and service modern wind turbines.

Our leadership in clean-energy generation also has drawn large, socially minded companies from outside of the wind industry to Iowa. Google and Facebook were attracted to Iowa in part because of our state's abundance of renewable energy, with both companies partnering with local utilities to directly purchase wind-generated power.

The state of Iowa is a leader in renewable energy today because of the commitment from stakeholders statewide. It was a journey that began in 1983, when Iowa passed the nation's first renewable electricity standard, a bill that I signed into law.

At that time, our state was almost entirely dependent on coal for electricity. That first law required investor-owned utilities in Iowa to own or contract for a combined 105 MW of renewable generating capacity.

Today, our state's utilities generate more than 6,200 MW of wind electricity, a figure that will continue to steadily grow. Our businesses and residents also have some of the lowest energy costs in the country, an important factor in Iowa, where advanced manufacturing is our leading industry.

Wind-power manufacturing itself supports 7,000 jobs in Iowa,

and turbine operators provide millions of dollars annually in lease payments to farmers. This economic impact cannot be overlooked, which is why I have supported, and continue to support, our state-level wind-energy incentives, as well as the federal government's renewable

electricity production tax credit (PTC). I commend the work done by members of Congress who voted to extend the PTC last December, which has restored a necessary level of predictability to the market.

Moving forward, we are planning for our state's future energy needs



with a coordinated state energy plan, which Iowa Lt. Gov. Kim Reynolds is leading in collaboration with stakeholders in the private sector.

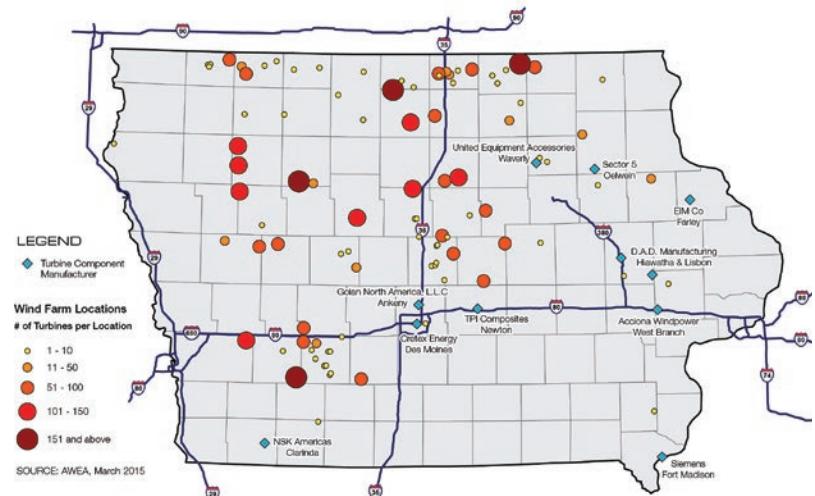
The plan, which is scheduled to be completed this fall, will include an assessment of current and future energy supply and demand, examine existing energy policies and programs, and identify emerging energy challenges and opportunities. The plan will also synthesize the existing state energy goals and strategies that are beneficial for the state, as well as outline new goals and strategies to position Iowa for the future.

The reasons behind Iowa's current leadership in wind generation extend beyond the fact that the wind blows strong and steady here. It started with forward-thinking policy, was augmented by our state's

business-friendly approach and has succeeded due to an all-in, collective effort. We are justifiably proud of where we are today, but it has

not chilled our ambition. We invite other states to follow Iowa into a future of cleaner, more sustainable power generation. ↗

WIND FARMS IN IOWA



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CONVERSATION

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Give us some background history on Iowa State University's wind energy programs.

The wind-energy science, engineering, and policy (WESEP) Ph.D. degree program began in 2012 in recognition that wind energy is the most economically attractive way to produce bulk quantities of greenhouse gas-free electric energy and that additional research is needed to further increase the percentage of electricity generated from wind energy and simultaneously reduce its cost.

The program began as a result of a \$3.1 million integrative graduate education and research traineeship (IGERT) award the university won in 2011 from the United States National Science Foundation (NSF), which supports the development of a new multidisciplinary, multi-institutional graduate training program of education and research in

WESEP at Iowa State (ISU) in collaboration with the University of Puerto Rico – Mayagüez. The purpose of this program is to meet the challenges of educating Ph.D. scientists and engineers in the U.S. with the interdisciplinary background, deep knowledge in a chosen discipline, and the technical, professional, and personal skills needed for the career demands of the future.

ISU also has an undergraduate minor program in wind energy with a number of courses available.

What sparked your interest in this industry?

I was an electric transmission planning engineer at Pacific Gas & Electric Company in San Francisco from 1985 to 1990. During my computer studies of the Western power grid, I modeled the Altamont Pass wind farm on the eastern side of the San Francisco Bay that was new at the time and the first in the nation. I became interested then because it was a novel technology, not because I thought it would ever play a significant role in supplying our nation's energy, which was a perspective I maintained until MidAmerican Energy built its first large-scale Iowa wind farm in 2004.

As a professor of electrical engineering at ISU, I began to study wind energy seriously. Very soon thereafter, I came to the conclusion that wind energy represented the nation's most promising electric energy generating technology and initiated research activities in this

area along with several colleagues in the department of electrical and computer engineering. This work began to expand in 2008 when the ISU College of Engineering (COE) organized a college-wide symposium on wind energy. Various people from multiple departments began collaborating, and when those efforts converged in 2011, we won the NSF IGERT award. One year later, we won a \$500,000 award from the ISU COE to establish the wind-energy initiative. Additional funding for wind-energy research came when a collaborative effort among the state of Iowa's Board of Regents' universities (ISU, the University of Iowa, and Northern Iowa University) won an experimental program to stimulate competitive research (EPSCOR) award from the NSF. The university organized a second symposium in September 2015 to increase collaboration with the wind-energy industry.

Why does the university believe pursuing careers in wind energy are beneficial to its students? What is its view on the state of the wind-energy industry here in the U.S.?

The wind-energy industry is still very new with a great deal of room for technological innovations. Therefore, there is a great need for researchers who are trained in this field. The wind industry is also growing rapidly with

wind energy comprising either the most or second-most added electric generating capacity in the U.S. every year since 2005, so the job market for engineers at both the undergraduate and graduate levels is very good.

The university believes that wind energy will continue to grow with Iowa as one of the leading states in the industry. With ISU's faculty expertise, the university is uniquely positioned to facilitate that growth by supplying both technological innovations and the needed labor force.

Tell us about the instructional philosophy behind the university's wind-energy initiative.

Wind energy is a highly interdisciplinary area of work, requiring knowledge and expertise in meteorology, statistics, and policy development together with almost all of the engineering disciplines including aerospace, mechanical, electrical, computer, industrial, civil, and materials science. This leads to a highly interdisciplinary approach to education where faculty from multiple departments 'team-teach' most of the courses. Students are trained to efficiently master the basics of each discipline and then identify how those basics are applied to WESEP. This inherent interdisciplinary training results in graduates who are comfortable and capable working across disciplinary boundaries.

What kinds of opportunities can students take advantage of beyond traditional classroom instruction at Iowa State?

ISU sponsors an NSF-supported research experience for undergraduates every summer, which is a 10-week program that chooses 10 to 15 undergraduates from applicants coming from universities around the nation. Each of these students receives \$5,000 plus lodging to participate and is expected to

complete a research project while in the program.

We also offer a weekly seminar series that WESEP Ph.D. students must enroll in every semester and that faculty and other students are welcome to attend. The most important function of this seminar is to expose students to a broad array of R&D and industry issues. Speakers from universities, industry, government agencies, and national labs are recruited from all over the U.S. to present. In addition, students are exposed to training in professional ethics, communication skills, and research methods.

We have four hardware laboratories on campus related to wind: the Wind Energy Manufacturing Laboratory run by the industrial and manufacturing systems engineering department, the Wind Simulation and Testing Laboratory run by the aerospace engineering department, the Wind Energy Systems Laboratory run by the electrical and computer engineering department, and the Structural Engineering Research Lab run by the civil engineering department. Some of the university's related research centers actively participating in wind-energy research include the Electric Power Research Center and the Center for Nondestructive Evaluation. These laboratories are also utilized in undergraduate education.

In addition, the WESEP Ph.D. program provides an international experience where a student identifies a university or research organization in another country to visit for two to six months to establish collaborative research activities.

Finally, ISU has established the Wind Energy Student Organization (WESO) that sponsors lectures, organizes educational visits to local K-12 schools, and supports various wind-energy-related projects on campus. This shows that WESEP students are motivated to inspire the next generation of wind engineers, and they have invested enough in the program to engage in

outside collaborative projects such as the 1-kW wind turbine project.

Tell us about the career opportunities available to students after graduation.

Employment opportunities for students graduating with training in wind energy can be found at the wind-turbine manufacturers (e.g., Siemens, GE, Iberdrola, and Vestas), wind-farm developers (e.g., MidAmerican Energy, NextEra, Horizon, etc.), grid operators (e.g., Mid-Continent Independent System Operator, PJM, California Independent System Operator, New York ISO, ISO-New England, Southwest Power Pool, Bonneville Power Administration, etc.), electric utility companies (e.g., Southern California Edison, Pacific Gas & Electric Company, etc.), national laboratories (e.g., Ames Lab, NREL, PNNL, LLNL, Argonne, etc.), government agencies (the National Weather Service and the National Oceanic and Atmospheric Administration, etc.), installation/repair/O&M (Bechtel, ABB, etc.), consultancy/engineering (e.g., Vaisala, AWS Truepower, Burns & McDonnell, etc.), and component manufacturers (TPI Composites, Trinity Towers, Schneider Electric, etc.).

We believe our WESEP graduates will not only be in high demand from the growing wind-energy industry, but they will also be in demand from other industries that place high value on students with interdisciplinary training, including any organization that is involved in production and delivery of energy of any form.

Because the first WESEP Ph.D. cohort began in Fall 2012, we have had only one student graduate at this point. That student is employed with NextEra, the largest owner of U.S. wind-power capacity, in Juno Beach, Florida. NextEra is the largest owner of wind-power capacity in the nation. There are presently 20 students in the program. ↗

A Strong Wind Blows Deep in the Heart of Texas

By Kenneth Carter





No one said Texas doesn't try to do everything big. So obviously, the Lone Star state's "bigness" is a point of pride in everything it does.

When it comes to the growing world of wind power, Texas is no exception: It leads the nation in wind-energy production.

If Texas were a country, it would boast the sixth largest wind-power capacity in the world, according to the American Wind Energy Association and the U.S. Energy Information Administration.

But the fact that a state whose history is steeped in oil and gas produces wind energy at all might come as a bit of a surprise to the average resident cranking up the AC in the middle of summer.

"That's part of the irony that we're a leader in oil and gas and that we're a leader in wind," said Dr. Michael Webber, deputy director of the Energy Institute, Josey Centennial Fellow in Energy Resources, co-director of the Clean Energy Incubator at the Austin Technology Incubator, and associate professor of Mechanical Engineering at The University of Texas at Austin. "So what it means is, I think, we're a leader in using our lands for economic purpose."

GEOGRAPHICALLY DIVERSE

Texas isn't planning on abandoning oil and gas. It still produces about 3.2 million barrels of oil a day. But Texas' geographically diverse regions make it ideal to explore forms of renewable energy – wind being at the forefront.

"Wind energy is a good example of how Texas is diversifying its economy thanks to the state's pro-business climate," said Tracye McDaniel, president and CEO of the Texas Economic Development Corporation.

The wind-power industry employed nearly 25,000 residents in 2015 with a total capital investment of \$32.7 billion, according to AWEA and EIA.

WIND IN TEXAS

Notable companies with operations in Texas include:

- Cielo Wind Power
- GRI Renewable Industries (June 2015 TEF offer)
- Duke Energy
- WinTex Energy LP
- Goldwind Global
- BP plc
- NextEra Energy
- TECO-Westinghouse Motor Company
- MFG Wind
- Alstom Wind

Source: AWEA, EIA

And experts say wind and Texas make a perfect fit.

"There are a couple of things that are favorable for wind. The resources are quite good," Webber said. "The other is we have growing demand for electricity, so we need more electricity because we have a growing population and a growing economy."

Bottom line is Texas uses a lot of electricity.

"The demand for electricity is growing in Texas in a way that it's not in other states," Webber said. "So we gotta build something. And then when you gotta build something, you look at your options to see what is the most competitive, and wind is one of the competitive options because it's cheap; it's pretty simple; it's got a policy that supports it, so wind is one of those options that's favorably treated."

RENEWABLE PORTFOLIO STANDARD

Texas established a renewable portfolio standard (RPS) in 1999, amending it in 2005. The current RPS required 5,880 MW of renewable energy by 2015. The state also has a target of reaching 10,000 MW of renewable capacity by 2025, which the wind-energy industry met in 2009. Wind energy has historically been the renewable resource chosen to meet RPS requirements, fulfilling 86 percent of RPS requirements through 2011, according to AWEA.

Following that RPS, Texas has invested billions in infrastructure development that included high-voltage power lines to link cities such as Austin with west Texas, according to oilprice.com.

"Texas made big investments in their electrical grid to make this transition easier and are very supportive of investors and operators participating in all aspects of the business: land owners, investors, manufacturers, suppliers, etc.," said John Mulhall, plant manager for GRI Renewable Industries, which is building a factory in Amarillo, Texas, to manufacture wind towers. The plant is scheduled to go online this summer.

WIND FARMS

Large wind farms in Texas include:

- Roscoe Wind Farm
- Horse Hollow Wind Energy Center
- Sherbino Wind Farm
- Capricorn Ridge Wind Farm
- Sweetwater Wind Farm
- Buffalo Gap Wind Farm
- King Mountain Wind Farm
- Desert Sky Wind Farm
- Wildorado Wind Ranch
- Brazos Wind Farm

Source: AWEA, EIA

WIND PROJECTS

- Installed wind capacity: 17,711 MW
- State rank for installed wind capacity: No. 1
- Number of wind turbines: 10,390
- State rank for number of wind turbines: No. 1
- Wind projects online: 116
- Wind capacity under construction: 5,486 MW

Source: AWEA

Those investments have let Texas dominate in wind production. It leads the nation in installed wind capacity at 17,711 MW as of 2015. And it has 10,390 wind turbines and two of the three largest wind farms in the western hemisphere, Roscoe Wind Farm and Horse Hollow Wind Farm, according to AWEA and EIA.

So wind is a good thing for Texas both environmentally and economically.

"It doesn't burn anything. It has no emissions, so it's very clean. That's the good news. The other good news is that it's pretty simple and cheap ... which is pretty favorable all the way around," he said. "The other thing is that it occurs in rural areas for the most part in west Texas and the panhandle, and so it brings jobs and that kind of growth to some areas that really need the money."

CONCERNING WIND

Ironically, a complication with the wind industry is the wind itself, Webber said.

"It's not always windy, and that's a challenge," he said. "It might be windy 30 percent of the time or 50 percent of the time, so it's not dispatchable or not firm power the way a traditional natural gas or coal-fire powered power plant might be."

But Webber said wind forecasting is getting better all the time.

"Wind forecasting in the last 15 years — especially the last seven years — has become quite good," he said. "Wind forecasting is really key to this. And if you predict wind well, it helps you manage the grid. In fact, wind today can be predicted more accurately than demand can be predicted."

But that grid also is improving, Mulhall said.

"The electrical grid has also been updated to meet the needs of wind-generated electricity as it flows into the grid," he said.

Companies exist now that are using science and meteorological conditions to better predict what the wind will be and where, Webber said.

Other companies also are taking advantage of the Tex-

CURRENT WIND GENERATION

- In 2015, wind energy provided 9.98 percent of all in-state electricity production.
- Equivalent number of homes powered by wind: 4.1 million

Source: AWEA, EIA

as landscape to build wind farms and harness this clean, renewable resource.

"Texas is a global leader in wind energy, with corporate giants like Google and Microsoft investing in wind farms to make their offices in the state 100 percent renewable," McDaniel said.

In addition to technology behemoths Google and Microsoft, a wind farm will supply the power for social media giant Facebook's new data center in Fort Worth, Texas.

"There are a lot of companies that build wind farms," Webber said. "For example, they'll build a farm and operate it, or they'll sell the wind farm to someone else. So wind developers will buy land or get a lease for land, and they'll pay to build a wind farm, and they'll operate the wind farm and sell the electricity, or they'll sell that wind farm to another operator."

WIND EDUCATION

The business sector in Texas isn't alone in pursuing opportunities in the wind industry. Education is tacking into the wind as well.

Texas Tech University's Wind Science & Engineering Research Center offers the first Wind Science and Engineering doctoral degree program in the country, according to AWEA and EIA.

Faculty and students research the efficient harvest of wind energy and mitigate wind-related damage. Some of TTU's wind-energy research goals include assessment of the risks and effects of wind-turbine exposure to extreme wind events, improvement of wind-turbine design codes and analysis and testing of utility-scale wind turbines, AWEA and EIA said.

And in July 2010, former Gov. Rick Perry announced an \$8.4 million Texas Emerging Technology Fund investment in the Texas Tech University system to achieve research superiority in the development of wind-energy collaboration.

TTU also is partnering with the National Institute for Renewable Energy, which will support the National Wind Resource Center, a nonprofit organization formed by TTU that focuses on wind-power research and education, according to AWEA and EIA.

THE BOTTOM LINE

Going green is a noble cause to be sure, but environmental-

ly friendly alternatives to energy production don't always pay the bills.

Not so with wind, because green also comes in the form of dollars.

"We're making a lot of money from wind, and it's a substantial part of our grid," Webber said. "So wind is relevant for sure. It's definitely relevant to those rural areas that are making a lot of money from it."

And the wind industry continues to grow with gale force in Texas with the next generation of wind energy moving into shallow waters — literally. Although that is still a ways off, Webber said.

"There could be some offshore stuff because we have some relatively shallow waters offshore in some really good wind resources," he said. "There's been a lot of interest, but nothing's really happened yet."

But as far as wind in general, there's nowhere to go but up, Webber said.

"The costs to generate electricity by wind are dropping and are now competitive with other means of generation," Mulhall said.

"It's going to keep growing," Webber said. "Wind is attractive for a variety of reasons."

TRADITIONAL ENERGY PROBLEMS

And with more environmental restrictions hitting traditional energy production, renewable energy sources such as wind can supply the demand that might be lost otherwise, according to Webber.

"If you build enough of the stuff, you'll displace others," he said. "That'll be driven a lot by environmental policy. There are tighter and tighter rules for getting rid of mercury and other toxic substances that are emitted from flue gases and coal plants, for example. As you tighten the rules on mercury, then there's pressure on the dirtier power plants to not operate, and as you have things shutting down, then you can replace that power with something else, and wind will have an opportunity to fill that gap." ↗

WIND GENERATION POTENTIAL

- The DOE Wind Vision Scenario projects that Texas could produce enough wind energy by 2030 to power the equivalent of 15.4 million average American homes.
- Land based technical wind potential at 80 m hub height: 1,418,439 MW
- Land based technical wind potential at 110 m hub height: 1,429,747 MW (Source: NREL)

Source: AWEA



Wind Future Grows Stronger

American wind power poised to quadruple by 2030.

By John Hensley

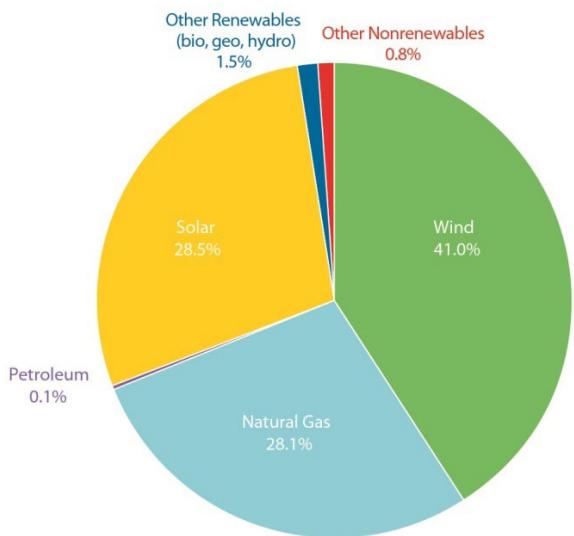


American wind power is on track to supply 20 percent of the country's electricity by 2030, a goal set in the Department of Energy's Wind Vision report released early last year. Following a near-record year of wind installments in 2015, activity in the U.S. continued at pace in the first quarter. In addition to 520 MW of new capacity, wind developers are constructing more than 10,000 MW of new capacity with a further 5,000 MW likely to start construction soon.

With new long-term, predictable policy certainty in place, the U.S. wind-energy industry is expected to continue this growth trend for the foreseeable future. Continuing cost declines, technological advances, and new customers recognizing the value of wind energy also will help keep this homegrown industry firmly on track to fulfill 20 percent of America's electric needs.

Nonetheless, lingering issues like transmission and policy still need to be addressed. It's necessary to allow the industry to con-

U.S. Percentage Share of Power Capacity Additions in 2015



tinue growing into one of the leading sources of American electricity, helping to garner new investment, create jobs, and keep the lights on in homes and businesses throughout the country.

STRONG GROWTH

Over the last five years, it's become clear that wind power is often the preferred source of new electricity. In 2015, it was the largest source of new electric-generating capacity, with more wind power coming online than solar or natural gas, accounting for 41 percent of all new generating capacity. Overall, wind is supplying roughly 5 percent of U.S. electricity, enough to power 20 million American homes.

At the state level, progress is even more impressive. Iowa now leads the nation, generating more than 31 percent of its electricity using wind. A dozen states now rely on it to supply at least 10 percent of their electricity. That includes Texas, which is particularly noteworthy considering the state is America's largest energy user. The industry is also expanding to new parts of the country. In 2015, Connecticut became the 40th state to host a utility-scale wind project, while earlier this year Guam became the second territory to build a wind

project. Activity in early 2016, catalyzed by the five-year extension of the production Tax Credit, indicates the industry will continue to grow rapidly. Just in the first three months of the year more than 2,000 MW of wind projects commenced construction with an additional 1,500 MW announced in late stages of development. In total, more than 15,000 MW of wind turbines are being erected now or in the near future.

Add to this total more than 660 MW of power-purchase agreements announced by utilities and companies like 3M and Salesforce, and it is easy to get a sense of the momentum building throughout the industry.

COST DECLINES DRIVE PROGRESS

Much of this growth is possible because wind power is increasingly cost-competitive with other energy sources. Today, the price of wind is 66 percent less than it was just six years ago. In many parts of the country, it's now the cheapest source of new electric generating capacity, as noted by groups like Politifact and Wall Street investment firm Lazard Inc.

Technological advances and improved domestic manufacturing are largely responsible for wind energy's

falling costs. Design improvements allow wind turbines to access stronger, steadier winds, increasing their efficiency and economic value in more places. For example, later this year North Carolina will become the 41st state with a utility-scale wind project, while the country's first offshore wind farm off the coast of Rhode Island is set to begin operations later this year. Just a few short years ago, technological restraints meant these efforts wouldn't have been financially viable.

The long-term policy stability provided by December's bipartisan extension of the Production Tax Credit has also made much of this progress possible, creating a business environment primed for success and unleashing American innovation.

WIND POWER GROWTH EQUALS JOB GROWTH

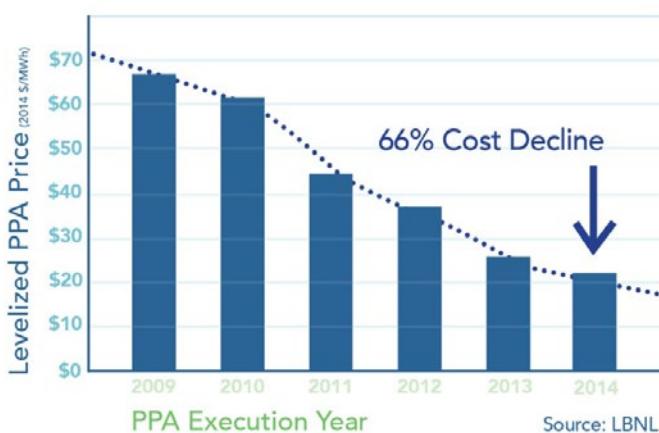
All of this growth means plenty of employment opportunity. Wind-energy jobs grew by 20 percent during 2015. At the start of this year, a record-high 88,000 Americans across all 50 states worked in the U.S. wind industry, including 21,000 manufacturing jobs at more than 500 factories.

With more than 48,000 wind turbines operating across the U.S., that also creates a strong need for people who can operate and maintain them. The wind-turbine technician is the country's fastest growing job, according to the U.S. Bureau of Labor Statistics. With the industry on track to double over the next five years and double again by 2030, the wind-turbine technician will continue to be an impressive source of job opportunity in rural parts of the country.

NEW CUSTOMERS DRIVE DEMAND

Wind power's falling cost and increasing long-term value has caught the attention of non-traditional buy-

FALLING COSTS OF WIND ENERGY



ers like Fortune 500 companies, cities, and universities, which have become some of wind energy's biggest new customers. These groups particularly like the price stability wind offers because it facilitates long-term and strategic planning. So not only does buying wind power help them achieve internal sustainability goals, it's also good for their bottom lines.

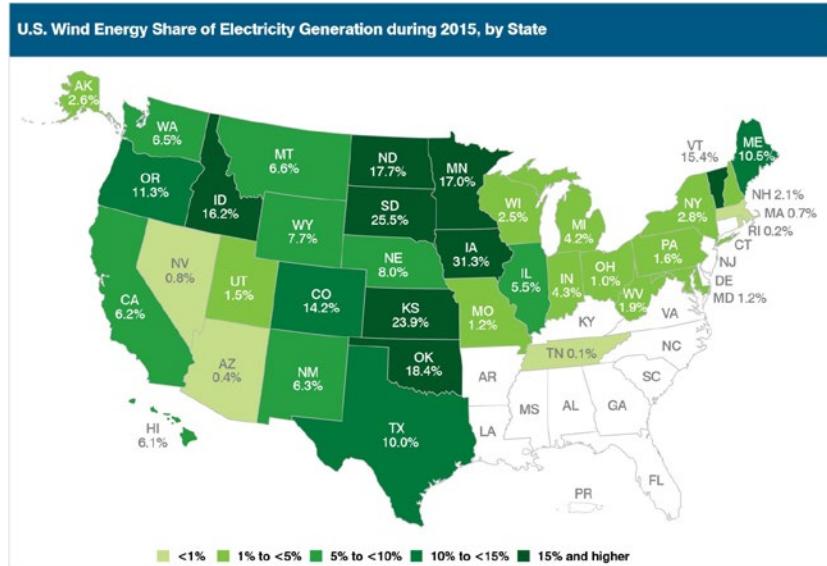
There were numerous high profile examples of this trend in 2015. Procter & Gamble bought enough wind power to produce all of its home care goods, like Tide and Mr. Clean, while General Motors purchased enough to build more than 120,000 trucks every year at one of its Texas factories. Meanwhile, Google and Amazon chose wind to power new data centers, and Washington, D.C., purchased enough wind to power more than one-third of the city government's operations.

The numbers show these examples aren't anecdotal. In 2015, more than half of the megawatts contracted through power-purchase agreements were signed by non-utility buyers. That's more than double the amount in 2014, and far more than 2013, where non-utility buyers signed a mere 5 percent of such agreements. Already this year, non-utility buyers have entered into power-purchase agreements for more than 240 MW of wind power, a number that will only grow.

THE AMERICAN PUBLIC LOVES WIND POWER

As an affordable, clean source of electricity that drives job growth, it's no surprise that support among the general public for wind energy is at an all-time high. A recently released poll from Lazard finds 91 percent of likely voters support growing wind power.

Importantly, Lazard found these sentiments cross party lines. Today, only 18 percent of self-described con-



servatives think transitioning toward a clean-energy economy isn't important. In 2012, that number was 46 percent. A majority of conservatives also think this transition is an issue of "most concern," up 17 points from four years ago, while nearly 60 percent support legislation that would grow renewable energy.

As George Bilicic, vice chairman and global head of Lazard's power, energy, and infrastructure group, explained, "Despite the polarized climate in Washington, voters' support for cleaner energy policies increasingly transcends political affiliation."

MOVING FORWARD

However, to keep this American success story moving forward, there are still obstacles that need to be overcome.

One of them concerns transmission. We need to build the necessary infrastructure to transport wind-generated electricity from the best resource areas to the towns and cities where electricity demand is highest. In the past, we built rail lines to transport coal and pipelines to transport natural gas. Now it's time to update the grid for 21st century needs.

Studies show this doesn't need to be an expensive endeavor, and it can actually result in a net benefit for consumers. A recent report from the Brattle group found \$47 billion in yearly electric bill savings for consumers from improved transmission planning. Other studies back this up. The Southwest Power Pool, a grid manager in 14 states, reports that transmission upgrades would save \$800 for each of its customers over the next four decades. Likewise, the Midcontinent Independent System Operator, which manages the grid in another 15 states, found similar improvements could save each person it serves \$1,000 in the coming years.

Experts estimate the U.S. wind industry will add about 9,000 MW per year through 2020, meaning strong growth will continue for the foreseeable future. Transmission expansion will be critical in ensuring this success.

The U.S. wind industry will continue working with its partners and champions to ensure that we stay on track to provide clean, affordable wind power for Americans across the country. ↗



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