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Wind Works for America

U.S. wind power is on track to supply 10 percent of the country's energy needs by 2020.

By John Hensley

The numbers are in — America's top renewable energy resource continues to grow, fostering economic development and delivering clean, low-cost energy across the country. Just as important, all the data indicate we can expect this growth to continue in the years ahead.

AWEA's *U.S. Wind Industry Annual Market Report, Year Ending 2016*, released in April, provides a complete picture of industry activity last year. Let's dig into the numbers and review the highlights.

They paint a clear picture: Wind works for America.

A LOT OF NEW WIND, MORE IN PIPELINE

American wind power now exceeds 82,000 MW of installed generating capacity, enough to power 24 million typical U.S. homes. That places it ahead of conventional hydropower as the country's largest source of renewable generating capacity and the fourth largest source of electric capacity overall.

This development spans the nation. Down south, North Carolina became the 41st state with a utility-scale wind farm early in 2017, while projects began operating throughout the Midwest and Plains states and even as far away as Guam.

More than 8,200 MW of new wind capacity came online in 2016, with significant amounts still to come. More than 18,000 MW remain under construction or in advanced development. Once online, these projects will provide enough new wind energy to power millions of additional American homes.

All of this new development means wind provides a growing share of our electricity mix. Wind supplied 5.5 percent of the country's electricity in 2016, and remains on track to supply 10 percent of America's electricity by 2020 — a goal set in the Department of Energy's Wind Vision.

At the state level, results look even more impressive. Iowa led the way by generating more than 36 percent of its electricity using wind, while South Dakota also topped 30 percent. North Dakota, Oklahoma, and Kansas all generated more than 20 percent of their electricity from wind turbines. Overall, wind produced more than 10 percent of the electricity in 14 states.

WIND GROWTH EQUALS JOB GROWTH

The U.S. wind industry also continued its role as a major job creator in 2016 — wind-related jobs total 102,500 and can be found in all 50 states.

More than 25,000 of these positions are manufacturing jobs at more than 500 U.S. factories that build wind-related parts and materials. This provides an important boost to a sector of the U.S. economy that has struggled for decades, and it helps bring new jobs to the places that need help the most, like the Rust Belt.

For example, Ohio leads the country with 62 wind factories, while Wisconsin and Pennsylvania have 26 each, and Michigan has 25. And while the Southeast has historically lagged in wind-farm installation, the region has a strong wind-manufacturing base, with more than 100 factories building components destined for wind turbines.

Wind supplied 5.5 percent of the country's electricity in 2016. (Courtesy: AWEA)

U.S. wind manufacturing will continue to grow. Wind-related manufacturing jobs could top 33,000 by 2020, according to Navigant Consulting — a gain of 8,000 new factory jobs by the end of President Donald J. Trump's first term.

Wind energy also brings jobs to rural America, another area that needs new opportunities.

Wind-turbine technician is by far the country's fastest growing job, according to the U.S. Bureau of Labor Statistics. Because 99 percent of wind farms are built in rural areas, wind-tech positions offer new jobs in places traditionally short on options. With the U.S. wind fleet now topping 52,000 turbines, with more coming in the years ahead, demand

ALSO IN THIS SECTION

Wind-related jobs should continue booming over the next four years. (Courtesy: AWEA)

is surging for operations and maintenance jobs.

Importantly, the U.S. wind industry proudly offers good jobs to the men and women who serve our country — veterans find wind jobs at a rate 50 percent above the average industry, based on data from the Department of Energy.

Wind-related jobs should continue booming over the next four years and could near a quarter of a million by 2020, according to Navigant Consulting. A deeper analysis of Navigant's report also finds manufacturing and installing each new turbine supports 18 full-time jobs.

UNMATCHED INVESTMENT IN RURAL AMERICA

The economic benefits of wind power extend far beyond job creation, however. Wind brings investment into rural America like few other industries.

"Wind energy, the fastest-growing source of electricity in the U.S., is transforming low-income rural areas in ways not seen since the federal government gave land to homesteaders 150 years ago," the Omaha World-Herald recently reported. "As commodity prices threaten to reach decade lows and farmers struggle to meet debt payments, wind has saved family farms across a wide swath of the heartland."

Wind power does this by offering the country's farmers and ranchers a new drought-proof cash crop — landowners hosting turbines received at least $245 million in lease payments last year. They can count on that income, which helps a lot in the thin-margin agricultural business. It offers stability in times of drought or less-than-ideal market conditions. For many families, wind-lease payments make the difference between continuing a multi-generational tradition and ending a way of life.

"We weren't making enough money to sustain ourselves," Richard Wilson, a Colorado rancher, recently told Bloomberg Businessweek. "Now we're in a position where we can operate our farm for another generation at least."

However, wind-turbine landlords aren't the only beneficiaries. Wind farms often pay the largest share of a county's taxes, substantially boosting local revenue. That adds new resources to county budgets, needed to pay teacher salaries, repair roads, or buy new snowplows. New wind projects will pay $8 billion in taxes over the next four years, on top of tax revenue from existing projects, according to Navigant.

Overall, wind is expected to drive $85 billion of domestic economic activity through 2020.

UTILITIES AND FORTUNE 500'S DRIVE DEMAND

Both utilities and non-traditional purchasers like Fortune 500 companies continue to drive new demand for wind.

America's large electric utilities have indicated they plan to continue adding more renewable energy to their electricity mixes. In April, PacifiCorp announced plans to add substantial new wind generation, upgrade its existing wind fleet, and build new transmission to open access to more wind energy.

"These investments will significantly increase the amount of clean renewable energy serving customers and reduce costs at the same time," said Stefan Bird, president and CEO of Pacific Power, the unit of PacifiCorp that serves customers in Oregon, Washington, and California. "This is a win-win and represents our continued commitment to both reduce the environmental impact of the energy we produce and keep costs low."

In 2016, both MidAmerican Energy and Alliant Energy committed to billion-dollar investments in new wind projects. Meanwhile, Xcel

Energy announced plans to develop new wind projects in seven states, including Minnesota, Colorado, New Mexico, and South Dakota.

"We're investing big in wind because of the tremendous economic value it brings to our customers," said Ben Fowke, Xcel's chairman, president, and CEO. "With wind energy at historic low prices, we can secure savings that will benefit customers now and for decades to come."

Large corporations also want to make more of their products using wind power.

Google expects to run all of its worldwide operations using renewable energy in 2017, sourcing 95 percent of that electricity from wind.

Earlier this year, Home Depot purchased enough wind for 100 of its Texas stores. GM bought enough wind power to run 100 percent of an Arlington, Texas, factory where the company builds 125,000 SUVs a year. And Amazon has agreements to run data centers in four states using wind energy.

"This pursuit of renewable energy benefits our customers and communities through cleaner air while strengthening our business through lower and more stable energy costs," said GM CEO Mary Barra, speaking about her company's pledge to transition to 100 percent renewable energy.

Both utilities and Fortune 500 companies remain enthusiastic about adding wind power because, in many parts of the country, wind beats all other generation sources on cost, and it's cost-competitive in many more. In fact, today wind costs 66 percent less than just seven years ago. Technological advances spurred by American innovation played an important role in this decline, allowing wind turbines to reach stronger, steadier winds, making more electricity more of the time.

Wind power remains on track to supply 10 percent of America's electricity. It creates new jobs and invests in the communities that need help the most. And many of the world's most successful businesses turn to wind as a solution for their energy needs. That offers plenty of proof that wind works for America.

Wind brings investment into rural America like few other industries. (Courtesy: AWEA)

John Hensley is the deputy director for Industry and Data Analysis for the American Wind Energy Association. He directs AWEA's analytical agenda through research and analysis on policies as well as collection and analysis of wind-energy market intelligence. Hensley leverages technology to efficiently collect, analyze, and distribute market data to AWEA members and stakeholders. He is responsible for AWEA's suite of data services including quarterly and annual market reports, the U.S. wind market database, an interactive wind industry mapping platform, and various other data products. Hensley holds a Masters of International Economics and International Affairs from the Johns Hopkins School of Advanced International Relations.

The Power of Data

Real-time data collection is being used to optimize turbine performance and profitability.

By Andrea Miller

The operations and maintenance of wind farms is experiencing a renaissance.

With the constant evolution of faster computers, instant data acquisition, high-speed processing, and advanced analytics, large amounts of data are available for real-time reliability diagnostics and prognostics and asset performance optimization.

Asset-related data now can be readily collected from various sources, such as the site SCADA systems, engineering reports, oil-analysis programs, vibration monitoring, and meteorological data, as well as maintenance-related data captured in a computerized maintenance management system (CMMS).

Apex Clean Energy, based in Charlottesville, Virginia, is going "all-in" on the power of data to fundamentally improve the performance, efficiency, parts life, and reliability of more than 1,700 MW of installed capacity for its asset management clients.

The process starts in a purpose-built, NERC-certified Remote Operations Control Center (ROCC), staffed 24 hours a day, 365 days per year. A first-tier software and proprietary network topology allows the ROCC operators full visibility and detailed access to each wind and solar asset under management.

Each day, these systems perform more than 1.6 billion scans of more than 58,000 data points with an average data pull every three seconds.

Apex Clean Energy's NERC-certified Remote Operations Control Center (ROCC) is staffed 24 hours a day, 365 days per year. (Courtesy: Apex Clean Energy)

The internally-coded advanced compression algorithm makes a history of about 250 million data points per day of high-resolution data that fuels advanced performance analytics and predictive failure analysis.

In simpler terms, these data points are sorted, prioritized, and analyzed to allow for real-time adjustments to maximize generation and revenues and minimize turbine downtime.

It's a glimpse of the future, in action today.

FROM REACTIVE TO PROACTIVE

Optimal performance and increased asset reliability and availability are two common goals among asset management teams across the wind industry. Unfortunately, many wind-farm operators are addressing these goals through a reactive strategy — that is, they are using only historical data to optimize assets for increased reliability.

This approach is typically used to address performance or reliability issues in response to asset failure or on prescribed calendar-based intervals and is not suitable for an entire class of assets given the particularities of the wind industry (i.e., varying environmental conditions from site to site, assets subject to different loads even at the same site, and so on).

Apex has implemented two platforms to address turbine and site

> Wind energy asset management is about maximizing wind-power generation.

Real-time data analytics can fundamentally improve the performance, efficiency, parts life, and reliability of wind farms. (Courtesy: Apex Clean Energy)

performance optimization and turbine life cycle reliability and availability. Both platforms were developed in accordance with the MIMOSA standards for operations and maintenance in manufacturing, fleet, and facility environments. There are six blocks of functionality in a condition-based monitoring system: data acquisition, data manipulation, state detection, diagnostics assessment, prognostics assessment, and advisory generation. Both of the Apex platforms address all six blocks of functionality.

DETECTING REAL-TIME DEVIATIONS

The Apex turbine performance and site performance optimization calculation engine is able to detect, in real time, deviations from nominal performance curves as well as from site averages. In addition, a set of engineering-based "crisp" rules — used with data-driven techniques — is employed to identify the underlying cause of underperforming turbines. Once such a turbine or site is identified as underperforming, a work order is opened in the Apex CMMS to be addressed by plant operations and site maintenance teams. Data compiled during troubleshooting activities is collected into a knowledge database that helps with future recommendations.

REMAINING USEFUL LIFE

The Apex turbine reliability and availability platform is focusing on optimizing each asset's remaining useful life (RUL) based on historic, current, and future asset operations. Current RUL is based on historical operating conditions and can be estimated as total accumulated damage (fatigue and extreme events) to a turbine major component. Future reliability and availability is then improved based on smart anomaly detection and improved asset management processes.

It is important to note that although high asset reliability and availability can always be obtained at high capital-expense and

operating-expense costs, Apex's platform balances all three to create an optimal operations and maintenance strategy.

Overall, wind energy asset management is about maximizing wind-power generation and profits over the long-term, and Apex is achieving significant results. It's about more than revenue, though. It's about keeping people safe, working with the local communities, and helping promote the power of clean, reliable wind energy.

APEX CLEAN ENERGY BY THE NUMBERS	
Assets Under Management	**$2.5 billion**
MW Under Management	**1,712**
Team	**35 professionals**

WHEN LIGHTNING STRIKES

Wind turbines are at increased risk of lightning strikes, and early damage detection is a crucial cost-saving measure. One case study of the power of real-time analytics is managing these scenarios.

Recovering from lightning damage on wind farms has historically been both time consuming and costly. Site operators are often faced with the decision to perform a site-wide inspection after each storm or risk waiting until the end of lightning season to do a thorough inspection for damage.

If an inspection is performed after every storm, site availability will suffer — personnel cannot address faulty turbines in a timely fashion, and costs increase if outside technicians are brought in. If inspections are postponed until the end of lightning season, damage to blades may have propagated by that time, and repair costs will rise significantly in turn.

To highlight the difficulty in this trade-off:

- Lightning often causes the joints between the blade shells to become separated. If a minor separation in the joint is caught quickly, then the repair can be done from a platform or ropes at a cost of $5,000 to $20,000. If the damage is not caught and the turbine goes on to operate, the joint will continue to separate, exponentially increasing the cost to repair it. There have been instances where the turbine shells separate completely; this is often referred to as a "banana-peel failure" and requires multiple cranes and extended turbine downtime. Costs in these cases can exceed $300,000.
- Many wind farms are comprised of hundreds of turbines, making a site-wide inspection to catch damages costly to perform. This situation is intensified when the lightning season can potentially bring 20 to 30 days of lightning storms and even more lightning activity during the winter months.

APEXDETECT

Sites managed by Apex's Asset Management team are monitored by the internally developed lightning monitoring system ApexDetect. Every lightning strike within the borders of an Apex-operated wind farm is processed in real-time to determine whether the lightning was within the likely strike zone for each turbine.

A database of likely lightning strikes to turbines — including the strike magnitude and direction — feeds automatic reports for site management following a storm, as well as an online tool that maps out the location of each relevant strike in relation to turbines at the site.

After a storm, site managers are able to do a targeted inspection of only the turbines struck by lightning. This ensures lightning damage is caught and repaired immediately to minimize repair costs and avoids unnecessary inspections being performed.

In 2015, a turbine at an Apex-managed wind farm was struck by lightning. Using the ApexDetect tool and process, the damage was detected immediately after the strike. The lightning had caused visible but small damage to the blade shell.

There was no auditory signature to the failure, so it is unlikely the damage would have been detected without an inspection. And although the visible damage was small, the lightning had in fact caused internal structural damage to the blade.

Immediate detection using ApexDetect and a timely repair prevented complete blade failure and a cost savings to the project of $300,000.

Andrea Miller is vice president for Asset Management at Apex Clean Energy. She brings 20 years of experience in engineering, operations, and asset management to Apex Clean Energy. Miller was previously with BP Wind Energy, where she managed a $1 billion-plus portfolio of wind-power generation facilities ranging from 60 MW to 600 MW. She has been successful in developing and commercializing new wind-generation facilities, maintaining contract and regulatory compliance, maximizing the profitability of the assets, and working with landowners, local regulators, environmental agencies, regional transmission operators, and utilities to bring the projects in on time and on budget. Miller holds a BS in civil engineering from Texas A&M University and an MBA from the Bauer College of Business at the University of Houston.

Leveraging Blade Management Software

EdgeData returns to WINDPOWER 2017 after a busy year of developing tools to improve its turbine-blade inspection software.

By Chris Shroyer

The days of mind-numbing hours reviewing hundreds, even thousands of wind-blade pictures to find the areas of damage, and classifying that damage, are soon to be going the way of corded telephones. Like that 20th-century relic, technological advancement has brought opportunities to create more efficient ways of conducting business. Advancement in robotics, image capture, data creation and management, and deep-learning artificial intelligence algorithms have created a new world of possibilities.

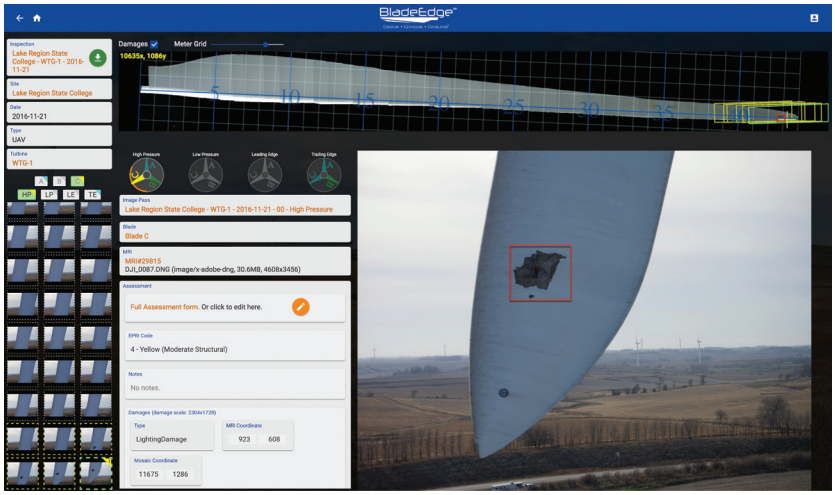
These technologies will be game changing in many industries, and wind energy is no exception. Images can be captured in multiple methods, but the real value is in leveraging the data produced in a way that efficiently solves business problems. Inspections by unmanned aerial systems (UAS, commonly called drones), robotic arms, or high-resolution spotting scopes are becoming more common every day — and they're proving effective. The real answers, however, lie within the data. How to best compute that data and consume that data?

It's been a productive year for the team at EdgeData. It entered the wind industry a rookie in 2016 with new ideas to improve wind-turbine inspections through deeper insight from raw data. After a year's worth of experience under their belts, the software is getting smarter. EdgeData isn't just a drone-flying company that captures images of critical utility infrastructure. During aerial blade inspections, it delivers high-quality images and metadata with BladeEdge℠, its patent-pending software solution.

Wind-turbine inspections with UAS are still new, and EdgeData is working to define the standard for flight procedures. (Courtesy: EdgeData)

Deep-learning technology recognizes and classifies damage, pinpointing the exact area needing attention at an entire blade and individual image level. Given time, the proprietary BladeEdge analytic software will track trends in wear and damage, and it can help operators determine proactive plans to develop budgets, maximize infrastructure lifecycles, minimize energy loss due to poor blade conditions, and proactively manage repairs to increase return on repair investments.

EdgeData operates under three process pillars: capture, compute, and consume. And it's not doing it alone. It has cultivated partnerships with industry leading organizations training the next generation of wind-turbine technicians and inspectors to capture data "the BladeEdge way." They're changing the wind-inspection game — at a foundational level.



Each time data is collected, BladeEdge further trains the software to recognize damage and anomaly areas on future inspections. (Courtesy: EdgeData)

CAPTURE

Wind-turbine inspections with UAS are still new, and EdgeData is working to define the standard for flight procedures. The work to capture the correct data, the correct way is the first step. Earlier this year, Oak Ridge National Laboratory enlisted EdgeData's advice on flight operations procedures and processes for flying near wind infrastructure. As the largest U.S. Department of Energy science and energy laboratory in the United States, Oak Ridge National Laboratory delivers transformative solutions to the challenges facing the energy and related security industries.

"We were honored to contribute to Oak Ridge National Laboratory's work," said Josh Riedy, COO at EdgeData. "Together, we're setting the standard for high-quality inspections across all industries, ensuring safety and productivity above all else."

EdgeData's UAS operator and team shared their flight operation procedures for wind infrastructure inspection via drone. An Early Survey of Best Practices for the Use of Small Unmanned Aerial Systems by the Electric Utility Industry was published in February, and it is regarded as a top resource for UAS specialization in the utility and energy industries.

EFFICIENCY IN THE FIELD

The software is only effective when high-quality raw data is correctly captured. With the UAS industry being so young and having many variables in the field, developing a means of capturing accurate data was essential.

EdgeData's BladeEdge Capture Assistance Tool (BECAT℠) was designed specifically for use in the field and ensures every drone always captures quality imagery. After completing an inspection flight, pilots can verify the data on a laptop, double-checking to be sure no square inch is left uninspected. With BECAT, EdgeData has taken a large step toward automated flight assistance. Whatever the inspectors' level of flying expertise, they'll be able to leave the field with the data needed to provide a quality inspection.

The tool also packages the imagery and all necessary meta-data for processing by BladeEdge's deep learning analysis algorithms. This saves time, and it can eliminate the possibility for human error. That means owners and operators have a complete, high-resolution close-up image of their infrastructure and do not need to spend hours reviewing each image. The anomalies have automatically been identified, located, and classified.

The BladeEdge software leverages deep learning technology to complete an automated assessment of the imagery captured in the field. Capturing overlap and pixel spacing in the field allows images to be stitched together into a single mosaic. This mosaic is color coordinated to highlight any damage or areas of concern. With each damaged area, the machine gets smarter and applies that knowledge to future inspections. This is the deep-learning layer of artificial intelligence.

Over time, owners and operators will be able to track wear patterns on blades and develop proactive maintenance plans to maximize the life of their infrastructure and increase annual energy production.

THE NEXT GENERATION OF INSPECTORS

EdgeData also is looking at the future of the wind turbine blade

inspection industry. In partnership with North Dakota's Lake Region State College (LRSC) in Devil's Lake, North Dakota, EdgeData is working to develop the next generation of wind-turbine inspectors.

LRSC's Wind Energy Technician Program is an associate in applied science degree, the first of its kind. The inaugural class graduates in May as aerial inspection enabled wind techs. Students have been learning in a hands-on environment, gaining real-world maintenance and repair experience on actual wind turbines.

The program now includes UAS curriculum, thanks to EdgeData, and students are working toward remote pilot certification under FAA regulations Part 107. Part of their coursework will include training on both BECAT flight procedures and the BladeEdge software. Graduates will be primed for jobs as inspectors in the wind-energy field. To date, the program has seen nearly 100 percent job placement for graduates.

COMPUTE: MAXIMIZING DEEP LEARNING

With the training of new wind technicians in the hands of LRSC and a network of partners and technology bringing flight-assist software, EdgeData can focus on software, big data, and deep learning technology that produce a top-quality inspection more easily and efficiently than ever before. Each time data is collected, it further trains the software to recognize damage and anomaly areas on future inspections.

Not all flying conditions are created equal. In a perfect world, UAS inspections would be conducted on bright, sunny days. But in reality, the weather doesn't always cooperate. BladeEdge was developed with tolerance for hazy or gloomy days and is effective in capturing blades against a gray sky. Even in poor conditions, pilots can capture complete image sets, delivering the data operators need to maintain their infrastructure.

In a perfect world, UAS inspections would be conducted on bright, sunny days. But in reality, the weather doesn't always cooperate. BladeEdge was developed with tolerance for hazy or gloomy days and is effective in capturing blades against a gray sky. (Courtesy: EdgeData)

UAS SPECIFIC DATA STORAGE

As EdgeData continues to grow, so does its need for data storage. All the big data must be processed and stored somewhere. The preference is that this data be stored near the processing points to minimize the need for transport of massive data sets. EdgeData has ambitions to create an environment custom-designed for the image treatment and machine learning algorithms critical to EdgeData and others in the drone image capture business.

EdgeData recently announced its intent to establish a 16,000-square-foot data center facility at Grand Sky, a UAS Business and Aviation Park in Grand Forks, North Dakota. Grand Sky is a highly secure, UAS specific environment and is ideal for a data center. The new facility will allow EdgeData to host an optimized environment for operations.

CONSUME

What does this all mean for the wind industry? It means manufacturers, owners, operators, and third-party service providers will have access to better data. With better data and complete imaging of their wind-turbine blades, they can make educated decisions for proactive maintenance and repair of damage. They'll maximize energy output while negating potential losses.

The entire methodology EdgeData has pioneered validates the importance of strong partner relationships that serve the industry as a whole. Capturing more data allows for longitudinal comparison of damages. Years of compiled data will show how wind-turbine blades degrade over time. It will track the impact of various climates on performance. The top causes of damage or wear will be identified. When raw data is turned into actionable intelligence, the value of this is only limited by our imaginations in how to apply what is learned.

Chris Shroyer joined EdgeData as a member of the entrepreneurial team of founders in 2015. Now, as president, he leads the execution of the business plan with his management team counterparts. His areas of focus include client relationships, strategic partnerships, new-market development, and revenue growth for the organization. Prior to his work at EdgeData, Shroyer was vice president of Sales and Marketing at Involta, an award-winning data center and technology services company that spent multiple years on the Inc. 5000 List of America's Fastest-Growing Companies, reaching No. 40 at its peak of growth. Shroyer's background spans more than 30 years of high-growth experience in technology sales and service, including work with market leaders such as Hewlett-Packard and other Fortune 100 organizations.