Feature—Wind, Sun, and Water

EPRI R&D Helps Utilities Better Understand the Promise and Challenges of Renewable Energy

By Chris Warren

Traditional wind turbine inspections can be risky and ineffective. Rappelling the turbine blades and working atop tall towers in windy conditions raise safety concerns and requires shutting down turbines. Standard visual inspection can identify degradation only on turbine blade surfaces.

John Lindberg, an EPRI program manager with decades of experience with maintenance and nondestructive evaluation of nuclear plant components, and EPRI's Renewable Generation R&D staff are collaborating to apply the benefits of nondestructive inspection to renewable generation technologies. Their initial focus is evaluation of wind turbines and blades.

"Most inspections are visual examinations done either by workers on the ground or rappelling from the top of the wind turbine and looking at the blades," said Lindberg. "You can't see if there are problems in the subsurface that could impact the structural integrity of the blades."

Lindberg worked with Digital Wind Systems during the development and testing of SABRE™*, Digital Wind Systems' tool that enables workers to more safely conduct inspections from the ground. SABRE™ has demonstrated an ability to identify potential problems before they become serious. "It can enable wind operators to address degradation long before blades fail," said Lindberg.

The SABRE™ system can be used to inspect the blades while the wind turbine is operating. EPRI estimates that SABRE™ could save operators hundreds of dollars per inspection in avoided lost power production, depending on turbine output, electricity prices, and downtime required for a visual inspection.

According to WindPower Monthly, nearly 4,000 blades fail each year. Replacing them can take units offline for days, weeks, or even months and cost tens to hundreds of thousands of dollars for repairs, replacement, and lost revenue. SABRE™ combines three technologies that can support more in-depth, ground-based inspections.

When placed close to a moving turbine, SABRE™'s thermography sensor detects temperature variations on the blades. "A flaw such as a crack creates a hot or cool spot that is one or two degrees different from the surrounding area," said Lindberg. At the same time, SABRE™'s microphones can pick up unusual noises. For

example, a smoothly operating blade produces a muffled sound as it rotates while a blade with a small hole may whistle. SABRE™'s acoustic spectral analysis uses algorithms to help locate the abnormal noise. SABRE™'s camera can then help to pinpoint the location of flaws identified by thermography or acoustic spectral analysis. EPRI continues to examine SABRE™'s potential performance in certain weather conditions, such as rain, fog, and high humidity.

In demonstrations over the past two years, more than 1,800 blades have been inspected at wind farms in Pennsylvania, Texas, Michigan, Minnesota, and Wisconsin. Significant blade anomalies detected by SABRE™ prompted operators to take turbines out of service for repairs and replacements, supporting safe, reliable, cost-effective power generation.

Applying EPRI Experience from Other Sectors

The work on SABRE™ exemplifies how EPRI is applying lessons, experience, and expertise from fossil and nuclear generation to help advance R&D on renewables such as wind, solar, and hydropower.

"Solar and wind are becoming a much larger portion of the generation mix," said Tom Alley, EPRI's vice president of generation. "We have deep experience in operations, maintenance, and performance of coal, nuclear, and gas assets, and can provide value to our members by using this expertise in the renewable arena."

For example, one project in 2016 will examine corrosion of steel solar panel racks in utility-scale installations. Parts of the racks are sometimes underground, where soil pH and moisture can lead to corrosion, compromising structural integrity. EPRI plans to develop guidelines on the use of buried structural steel and then conduct laboratory and field tests to inform the selection of materials for solar projects.

"Until recently, EPRI's materials program focused on steam turbines and boilers," said Alley. "The solar racking work highlights how we are broadening the program's R&D to materials used across the range of power plant components."

Solar Performance, Short and Long Term

As power companies deploy more solar generation, they want to accurately predict their facilities' performance and reliability. "Utilities are keen to learn whether the capacity listed on a solar panel's nameplate is accurate and how production changes as the result of positioning, snowfall, and temperature," said Cara Libby, EPRI senior technical leader in renewable energy.

In 2012, EPRI installed eight 10-kilowatt solar photovoltaic (PV) systems using crystalline silicon and thin-film panel technologies on its test site at the Solar Technology Acceleration Center (SolarTAC) in Aurora, Colorado. Three years of continuous monitoring identified the manufacturer's nameplate rating as the greatest source of uncertainty in predicting performance. The data suggests that panels generated as much as 7% above and below the rating.

In seasonal tests, temperature exerted the biggest impact on performance, with higher efficiency in cold winter months. Initial results suggest that thin-film PV panels composed of cells in horizontal strings recover faster after snowfall than crystalline silicon panels with vertical strings. The rows of cells at the top of thin-film panels can produce current as the snow begins to melt.

These insights can help inform utilities' decisions on solar, enabling them to make better asset and operations choices that benefit the public through more cost-effective, reliable power generation. "By reducing performance uncertainty, this research has tremendous strategic value for utilities considering generating, purchasing, or integrating solar into their portfolios," said Nadav Enbar, a principal project manager at EPRI.

At Southern Research in Birmingham, Alabama, EPRI is studying how solar panels perform after 10, 15, and 20-plus years of operation. Because widespread solar deployment is relatively new, little is known about long-term panel degradation and its effect on performance.

In 2016, EPRI will begin accelerated aging tests in the laboratory. “In just a few months, these tests can simulate decades of temperature variations, high humidity, and other harsh outdoor conditions,” said EPRI Project Engineer Chris Trueblood. To help validate the results, EPRI will compare panels subjected to accelerated aging with those subjected to several years of operation.

Collaborating with Utilities

Over the past decade, Minnesota-based Xcel Energy has seen customer demand for renewables shift from wind to solar. “Now we’re seeing strong customer demand for solar in our territory, and it’s becoming a much more cost-effective solution,” said David Stevens, project manager for Xcel Energy’s Emerging Technology team.

To bring more solar power online while ensuring grid reliability and safety, Xcel Energy seeks a deeper understanding of potential impacts on distribution grid voltage. “These distributed resources are tied to the grid at a much lower voltage than wind plants,” said Stevens. “We want to make sure that a large increase in intermittent solar generation doesn’t impact grid reliability, and we want to be clear on the benefits and limitations of energy storage.”

Xcel Energy and EPRI are working at SolarTAC to evaluate the benefits of pairing solar with various battery technologies. For four years, they monitored an 850-kilowatt concentrating photovoltaic system connected to a 1.5-megawatt-hour lead-acid battery with capabilities such as smoothing of solar generation and time shifting. They also evaluated the performance of a 50-kilowatt-hour sodium nickel chloride battery coupled with kilowatt-scale solar arrays serving loads intended to approximate four residences.

The projects have yielded important lessons for Xcel Energy. “We know a lot more about how well the batteries respond to the intermittent generation of solar, how the battery chemistries perform over time, what energy storage management systems offer now, and where they need to be tomorrow,” Stevens said. “The research at SolarTAC has prepared us to move forward with battery demonstration projects in real-world distribution systems.”

EPRI, Southern Company, and its subsidiary Georgia Power are analyzing the performance of a 1-megawatt solar installation in Athens, Georgia. “A lot of utilities are interested in utility-scale solar,” said Chris Trueblood. “The Athens facility will reveal how different panel orientations and other system configurations impact performance at this scale.”

At the Athens installation, EPRI also is testing grid support functions of smart inverters. “The inverters can help adjust the voltage quality on distribution grid feeders,” said Trueblood. “Understanding the real-world effects of these functions will help utilities integrate megawatt-scale solar generation into the distribution grid without impacting reliability.”

Optimizing Hydropower

In 2016, EPRI is ramping up R&D on operations, maintenance, and performance of hydroelectric power plants, considering advice from members on priorities.

A recent EPRI study revealed the potential generation and financial benefits of more active management of hydro operations. The report notes that there is room for improvement in the number of plants that optimize operations by finding the “sweet spot” where a turbine’s power generation is maximized while water flow is

minimized. As grid operators impose changing demands on hydro plants, the challenge is to operate turbines more flexibly.

For instance, if there is excess power in the region, grid operators may ask plant operators to curtail generation by reducing water flow. EPRI's research shows that there can be a big financial upside to determining which units receive less water. For example, in a five-unit hydro facility, it may be more cost-effective to let three of the turbines operate at full capacity all the time and cycle the other two units up and down. Recent EPRI R&D shows that newer hydro turbines might offer improved generation performance but at the cost of more limited flexibility.

As utilities' needs change, so too will EPRI's renewable energy R&D. Tom Alley points out that just a few years ago, most utilities were not interested in owning large wind and solar assets. "We are seeing that change," he said. "For us to be relevant to our members, we have to be relevant in the renewable area. And we will through our public benefit research."

*SABRE™ is the trademark of Digital Wind Systems, Inc.

Key EPRI Technical Experts

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