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Global Teamwork on Pandemic Response

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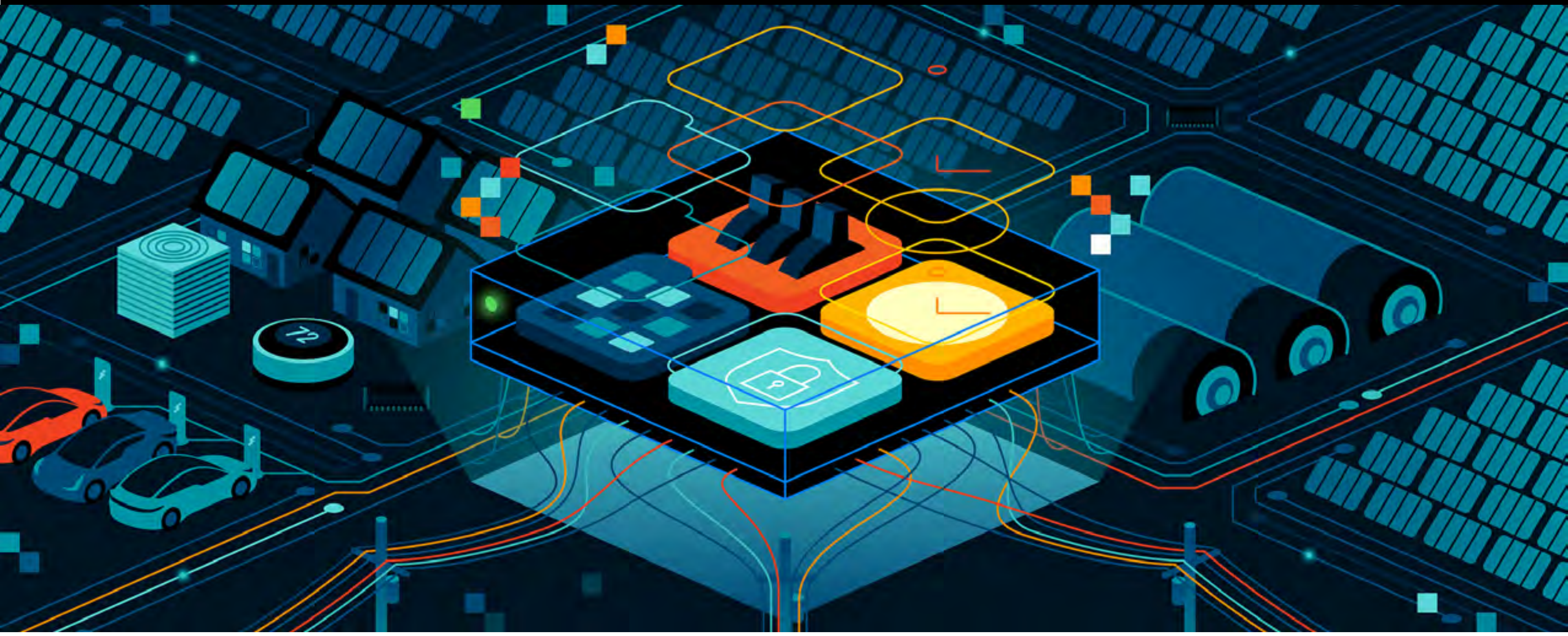

The Network Gateway: The Missing Link for Integrating Distributed Energy Resources?

By Michael Matz

With growing deployment of grid-connected rooftop solar photovoltaic (PV) systems, energy storage, and electric vehicles, electric utilities need to anticipate and find solutions for potential unintended side effects that may occur as a result of these distributed energy resources (DER). An example: On a sunny spring day with low customer load, a utility's distribution grid operator notices that generation from a number of solar systems is likely to exceed load significantly, potentially causing an overload on the grid. The grid operator sends a command to an aggregation of DER to limit its output to the grid, but the command does not reach the DER due to a communications network failure, resulting in local overvoltage conditions and potentially customer outages.

This hypothetical scenario points to the need for DER to have default modes that a utility can pre-set in anticipation of network failures. In this example, if the utility had set a default mode limiting DER output during contingencies, the DER aggregation would have operated as needed even during a network failure, averting potential reliability problems.

The default mode (also known as the fail-safe mode) is one of more than a dozen new DER capabilities that utilities expect will be needed in order to manage DER effectively and reliably. This raises the question, where would these capabilities be housed and how should they be defined?

EPRI researchers and other DER integration, communications, and cybersecurity experts see a network gateway as a promising solution. A gateway is a device that connects communication networks that use different languages, translating those languages so that devices on one network can talk with devices on the other network. At a system that combines solar and energy storage, a gateway would connect the system's local network (which may include communication among inverters, solar PV, and energy storage) with the network of the utility, vendor, or aggregator that is managing the system and other DER in the region.

"Tomorrow's grid will be powered to a significant extent by different models and types of DER that are managed by diverse entities, including utilities and aggregators," says Ajit Renjit, an EPRI expert on DER control systems. "Integrating all these resources over large geographical areas needs to be done in a secure, cost-effective, durable way. The gateway offers a promising solution because it's located at the DER site, it is a low-cost device, and it doesn't require any additional hardware to accommodate numerous DER functions and capabilities. For the gateway to work, it will need to be interoperable with DER and utility or aggregator management systems."

A NEED FOR FLEXIBILITY IN DER FEATURES AND FUNCTIONS

As DER have become more widespread, utilities and regulators have sought new tools to integrate them with grid planning and operations. An important initial step in 2018 was the publication of a revised IEEE 1547 standard, which requires that smart inverters include a communications port and various grid-support functions, such as the ability to provide voltage and frequency support. However, the standard does not specify many critical DER features and functions that are necessary for utilities and aggregators to monitor and control DER in a comprehensive way.

"The industry experts who developed the IEEE 1547 standard intentionally made the DER requirements simple," says Renjit. "It omitted certain DER features and functions that are expected to vary by utility and region. The gateway approach provides a practical implementation path to house such features and functions."

An EPRI-convened utility working group is identifying potential gateway applications and defining functions. Other discussion topics include determining the gateway's physical location at a DER site and recommending gateway function refinements and commercialization strategies. The group currently has 13 participating utilities, meets every two weeks, and is open to new members.

"The utilities on the working group are already managing DER in their service territories, so they have experience in determining what capabilities are needed in the gateway," says Renjit. "They have proposed more than 20 gateway applications so far, and EPRI is presently researching how these applications could be incorporated in a gateway."

"Innovation and advanced grid management are key to achieving North Carolina's electric cooperatives' long-term vision of building a brighter future for members and local communities," says Lee Ragsdale, senior vice president for energy delivery at North Carolina's Electric Cooperatives. "This collaborative study identifies future applications for gateway systems and new ways to connect our centralized DERMS to remote energy resources, allowing us to more efficiently and effectively manage these resources and deliver additional value to our members."

FAIL-SAFE MODE, CYBERSECURITY, AND UNIVERSAL CLOCK

The fail-safe mode is one of the 20 applications under investigation. IEEE 1547 did not specify a fail-safe mode for DER because settings will vary among utilities and other DER management entities. Additionally, utilities will need flexibility to configure different fail-safe triggers because of varying performance of different utility communication systems. For instance, a 10-second loss of communications may indicate a network failure for some utility systems but not for others.

A second potential gateway application is cybersecurity. IEEE 1547 does not require DER to support cybersecurity measures. Without comprehensive cybersecurity requirements and guidelines, each DER manufacturer may implement a unique or limited set of cybersecurity features in its products. This can cause DER to become less interoperable with utility control systems.

"Utilities need to securely connect their control systems with the disparate systems that make up DER sites," says Xavier Francia, an EPRI expert on DER cybersecurity. "It would be complex and unwieldy to try to achieve this by configuring their control systems to accommodate DER sites with components made by different manufacturers and equipped with different cybersecurity features. A gateway is a more practical approach to protecting utility control systems from threats introduced through a site's various access points, enabling more robust security."

A third critical function envisioned for the gateway is time synchronization (also known as a universal clock). Scheduling plays an important role in how utilities manage and control DER. For DER to execute utility commands when needed, the internal clocks of DER and utility systems must be synchronized. Consider this scenario: a utility's grid operator determines that an aggregation of DER is causing local reliability problems. The utility's DER management system decides that these DER need to limit their output in three hours to mitigate the situation. Because significant grid events can strain communication networks, the utility system sends the commands to the DER in advance of when the output is needed. Equipped with a universal clock, the DER gateways receive the commands and execute them on time.

The gateway must handle various communication protocols with equal facility so that it can respond effectively to signals from utility, vendor, and aggregator systems. "Communication technologies and interoperability are essential for cost-effective, secure monitoring and management of gateways," says Rish Ghatikar, an EPRI expert on information and communication technologies for DER. "Gateways can support grid reliability as long as there are robust requirements for communication protocols. This research can inform standards organizations such as IEEE in their efforts to create such requirements."

In 2021, EPRI researchers plan to develop a gateway prototype that will be used to test the proposed applications for technical feasibility. To gauge economic viability, they will estimate manufacturing and deployment costs associated with each application. "This research will help us develop guidelines that can enable utilities to define their own gateway requirements," said Renjit.

"It is clear that smart inverters provide value to both DER owners and grid operators," says David Lovelady, a grid modernization solutions engineer at National Grid. "But as utilities implement more advanced smart inverter functions requiring bi-directional communications, a loss of communications can challenge their ability to manage the grid safely and reliably. The gateway being developed by EPRI and several utilities can potentially mitigate this concern through a new function that would provide local, autonomous control of a smart inverter in the event of a communications failure."

KEY EPRI TECHNICAL EXPERTS

Ajit Renjit, Xavier Francia, Rish Ghatikar

EPRI JOURNAL

Global Teamwork on Pandemic Response

EPRI enables more than 300 companies to share innovative practices for transmission and distribution operations

By Michael Matz

In mid-March 2020, during the early stages of the coronavirus pandemic, the utility National Grid sequestered hundreds of its grid control center staff in the Northeast U.S., setting up onsite trailers and RVs, meal and laundry services, and daily medical screenings. The intent was to isolate them at the centers for several weeks to minimize the chance of infection. The move was unprecedented. Just days later, EPRI facilitated a webcast with hundreds of grid operations staff around the world during which National Grid's Transmission Control Center Manager Matthew Antonio provided a detailed presentation about the steps implemented. In the middle of his presentation, Antonio revealed that he was personally sequestered at a control center.

"It was remarkable that Matthew took the time while in the middle of a major crisis to share his insights and support the global power industry," said Brian Deaver, an EPRI expert on distribution grid operations and a webcast facilitator. "Another grid operator who was personally sequestered—Aaron Markham from New York Independent System Operator—also shared his experiences on the webcast. You could feel the impact on the webcast audience—and a sense that we were all in this together. There also was a sense of appreciation among the participants, since they could use this valuable information to adjust and adapt their control center practices during the rapidly changing pandemic."

The webcast was one of a series of more than 20 webcasts convened by EPRI in March, April, and May 2020, with an aim to facilitate sharing of pandemic-related experiences, challenges, innovations, and lessons among distribution and transmission grid operators. The series was attended by more than 7,400 participants from more than 360 companies on all continents (except Antarctica), mainly transmission, distribution, and field operations staff.

"Given that this was a global pandemic, EPRI recognized that every utility in the world was experiencing the same challenges at nearly the same time, so we invited all power companies—not just

EPRI members—to attend the webcasts," said Adrian Kelly, an EPRI expert on transmission grid operations and a webcast facilitator. "This is in line with EPRI's public benefit mission. Our thinking was that the more power companies could collaborate and share experiences, the more effective they would be in meeting their customers' needs."

While most webcasts had a global scope, some were regionally focused. For example, a Latin American, Spanish-language webcast was attended by 240 people from 53 companies in 13 countries. Some webcasts combined transmission and distribution issues while others focused on one or the other. A publicly available EPRI report, *Powering Through Together*, summarizes the strategies and insights discussed during the series.

"In control centers across the globe, transmission and distribution grid operators draw on specialized skill sets and decades of expertise to implement finely tuned approaches," said Kelly. "A coronavirus outbreak among these critical staff could jeopardize the safe, reliable operation of the grid."

"Typically, control rooms are one large space where dozens of people sit close to each other. What can you do if someone gets sick with a highly transmittable and potentially dangerous virus?" said Deaver. "Initially, you could send everyone on that shift home to self-quarantine for 14 days and deep-clean the control center. You could only do that a couple times before you ran out of qualified control room operators—and that was the big concern."

Through the webcasts, EPRI facilitated information-sharing and insight-gathering as the power industry's pandemic response unfolded, enabling utilities to develop and adjust their practices in real-time. Discussions focused on topics such as sequestering staff, remote operations, control center design, cleaning, and health monitoring. EPRI polled webcast participants on various practices and distributed updates regularly.

"It was like a global talk radio show, with EPRI staff as the hosts and production team," said Deaver. "If we were aware of innovative practices at a particular utility, we would call on them to share this information with the group. In many cases, webcast participants were modifying their practices between webcasts based on what they were learning. The level of information-sharing and collaboration was extraordinary."

"The EPRI webcasts provided a global network that enabled peer review and validation across a much broader base of knowledge than what is normally available to any single power company," said Cyril Patterson, who manages grid operations at Manitoba Hydro. "When the pandemic began, Manitoba Hydro had to react quickly and decisively. By discussing these challenges with our peers around the world, our company was able to test and implement new practices in a matter of days—and ultimately develop a comprehensive set of control center and field work practices. Without the webcasts, we could not have accomplished so much in so little time."

"EPRI's webcasts gathered the best thinking in the industry," said Chuck Eves, Avangrid's vice president of electric operations. "They allowed us to make quick decisions with a high level of confidence and weather the pandemic with only a fraction of a percent of workers infected. We also used information from the webcasts to safely restore more than 500,000 customers in storms during the pandemic. EPRI's work was a big part of that success."

INSIGHTS FROM THE WEBCASTS: BACKUP SITES, SEQUESTERING, SAFETY, AND FIELD CREWS

One critical theme in the webcasts was the importance of a good site for a backup control center. Most utilities already have various types of alternate facilities for use during training, severe weather, and other emergencies. During the pandemic, many companies are rotating personnel between main and backup centers to enable regular cleaning. Most have split personnel into two teams so that if someone were to get infected on one team, the alternate team could continue working normally.

Some companies sequestered staff at their control centers, and the webcasts delved into the details—the durations, shift schedules, lodging, and logistics. As revealed in the webcasts, most companies that have not sequestered have established triggers for sequestering, based on metrics such as the percentage of staff calling in sick or under self-quarantine.

"Companies asked for volunteers to sequester, and the response rate was high," said Kelly. "Morale among sequestered operators was reported to be very high, with an 'in this together for the greater good of the company and society' mindset."

Control rooms have implemented social distancing practices, installing barricades and changing spacing between desks. A universal practice has been to issue personnel their own headset, keyboard, mouse, and stationary to limit the number of shared surfaces. Many control centers have gone paperless. Some have used larger screens or video-walls to reduce human contact. Utilities have reported that most of these practices will likely remain after the pandemic.

"Some companies have voluntarily reported to EPRI when staff tested positive for COVID-19, but thankfully these cases have been isolated," said Kelly. "There have been no reported outbreaks among control center operators anywhere in the world, demonstrating that the measures have worked."

The webcasts offered important reminders about staying focused on field crew safety. Even as control center operators may have concerns about getting sick, they need to properly send orders to open and close various switches to enable safe work areas for maintenance. "Given the potential distractions associated with the coronavirus pandemic, it is imperative that we stay focused on the safety of our field workers and the public," said Consumers Energy's Grid Operations Manager Kevin Reeser during one of the webcasts.

The webcasts provided the industry with numerous insights on field work and storm response. An example: Prior to the pandemic, some utilities had established capabilities to transfer limited grid control functions to field crews to ease the control center's workload during severe weather. This option has proven helpful during the pandemic.

Traditionally during storms, field workers gather at central locations to pick up equipment and coordinate emergency operations—an approach that could increase the risk of a COVID-19 outbreak. Early in the pandemic, utilities adopted new strategies such as convening workers in multiple, distributed areas and using digital communications for work assignments, safety clearances, document transfers, and situational awareness.

During storms in North America in April 2020, these practices generally worked well, though challenges emerged. Some field activities occur in tight locations where physical distance is not possible. Others may require more than one person to handle the same equipment or drive in the same truck. Companies such as Manitoba Hydro developed and implemented detailed procedures to reduce the risk of infection in such situations, sharing them with the industry during the webcasts.

As part of its response to tropical storm Isaias in New Jersey in August 2020, First Energy modified its procedures in numerous ways to accommodate COVID-19. To enable social distancing, First Energy set up additional staging sites for workers from other utilities. Onboarding attendance was limited to 10 people instead of about 50 in normal circumstances. Meals were packaged individually instead of buffet style. Masks, handwashing stations, and hand sanitizer were provided. Sleeping arrangements were modified by providing more trailers with fewer bunks each and by assigning one person per hotel room. Many storm response support activities were performed remotely instead of at the distribution control center.

To limit outbreaks among field crews, many utilities canceled or deferred a portion of spring 2020 maintenance outages on distribution and transmission grids—activities that are necessary for safe, reliable grid operations but that typically require multiple workers gathering at a site. EPRI and power companies are examining the impacts of these deferrals.

COMPREHENSIVE COVID-19 RESEARCH UNDERWAY

The webcasts provided a unique opportunity to identify critical research needs. Informed by input from the participants, EPRI has launched a multi-faceted research project to develop rigorous technical bases for pandemic-resilient transmission and distribution systems. The project builds on the global collaboration and innovation set in motion by the webcast series. Topics include health monitoring and testing, disinfection methods, control center designs, field crew operations, asset management, and long-term impacts on decarbonization and sustainability.

One priority is to determine how control room staff can work remotely from home. Some distribution control centers had already implemented remote operator capabilities before the pandemic for various reasons (such as preparing for severe weather), and these capabilities have proven valuable now. However, remote transmission grid operations are not allowed per North American Electric Reliability Council's Critical Infrastructure Protection guidelines.

"It's very difficult to set up new capabilities such as remote operations 'on the fly' during a pandemic because of the complex cyber security, communications, and training issues that need to be worked out," said Deaver. "EPRI plans to develop tools and practices to help utilities establish these capabilities."

Can remote work tools support operator training as well? "Traditionally, a control room trainee sits beside an experienced operator for hundreds of hours," said Kelly. "This is not possible in a pandemic. Utilities need to train new staff because they may have to replace a large number of existing staff in an outbreak. EPRI plans to examine computer-based training techniques and expand the number of remote courses offered by EPRI U."

Another key research area is design of main and backup control centers. "How can centers be redesigned for more space and sanitation capabilities?" said Kelly. "What disinfectant technologies can be used and how should they be deployed? Will more control center functions be automated? These are all important research questions that we plan to explore."

Other research plans include tools to schedule maintenance outages, storm response practices, and storm restoration tools and processes.

"I think we should all strongly commend transmission and distribution operators around the world who quickly and safely implemented creative, out-of-the-box mitigations to adapt to this crisis," said Deaver.

EPRI's Distribution Operations Interest Group Laid the Groundwork

Since 2012, EPRI's Distribution Operations Interest Group has convened distribution grid operators and managers two times per year to discuss and share experiences related to deployment, operation, and maintenance of control room technologies. More than 250 distribution operations professionals from about 75 utilities participate. The long-standing professional relationships built through this group helped lay the groundwork for EPRI's series of pandemic-related webcasts in 2020. Many of the webcast panelists are active members of the interest group, which is part of EPRI's Distribution Operations and Planning Program. Contact Brian Deaver (bdeaver@epri.com) for more information.

KEY EPRI TECHNICAL EXPERTS

Brian Deaver, Adrian Kelly

Power Plants During the Coronavirus Pandemic: "A Good Path Forward"

A series of EPRI-facilitated webcasts enabled nearly 2,000 people from 122 utilities in 19 countries to share pandemic strategies and practices for power plant operations

By Michael Matz

During the COVID-19 pandemic, some power plant operators purchased dishwasher-safe keyboards, mice, and other office accessories and provided employees with their own sets. Early in the pandemic when there were widespread shortages of hand sanitizers, several plants used their in-house chemical laboratories to manufacture their own sanitizers. These were just a few of the many creative pandemic strategies and practices that were shared among power plant operators across the globe during a series of EPRI-facilitated webcasts in March and April 2020.

Nearly 2,000 people from 122 different utilities in 19 countries attended six webcasts. Participants included plant managers, maintenance managers, health and safety personnel, and corporate staff. Plant operators presented on their experiences, lessons, and practices related to sequestering staff, cleaning, maintenance, deliveries, and much more. Participants asked questions and engaged in open discussion.

Common practices shared and discussed during the webcasts:

- Sequestering control room staff (particularly in high-impact states such as New York, New Jersey, and Michigan)
- "Locking down" plant control rooms so that only essential staff can enter
- Staggering shifts to reduce number of staff in facilities
- Screening people entering sites for potential infection using questionnaires and temperature tests
- Non-essential staff working from home
- Management staff working on rotation—some in the plant, some at home
- Deep cleanings of control rooms (such as disinfectant fogging)

- Setting up auxiliary control rooms where staff could work while fogging was performed in the main control room

"The overall picture from the webcasts is that power plant managers had solid plans in place and felt like they had a good path forward during the pandemic," said Dwayne Coffey, an EPRI expert on the roles of people, processes, and technology in power generation. "They had a good basis to start from. Many plants already had staff sequestration plans for severe weather and simply modified them for longer periods."

"The webcasts have proven invaluable for looking at best practices to manage COVID-19," said Mark Field, who manages operations for an RWE power plant in the United Kingdom. "From each call, we were able to take learning points back for further discussion and development across our sites in the UK."

Common challenges included obtaining cleaning supplies, personal protective equipment, and testing kits. Many plants delayed or deferred previously scheduled maintenance outages, in which up to 200 temporary workers converge on-site for 20-60 days to conduct work around the plant. Other operators moved forward with outages while screening workers upon entry and implementing social distancing.

Power plants had to alter their "lockout/tagout" safety procedures used to verify that potentially hazardous machines and power sources are properly turned off before maintenance can occur. Traditionally, operational and maintenance staff meet face-to-face for this process. Plants implemented various solutions, such as plexiglass screens, wearing masks, or staying at least six feet apart.

DIGITAL TECHNOLOGIES TO ENABLE SOCIAL DISTANCING

EPRI's Coffey is examining the pandemic's longer-term impacts on worker performance and culture in power plants. "Traditionally, staff are encouraged to have a questioning attitude, which often involves asking your colleagues questions and other face-to-face interactions," he said. "How does this change in a pandemic and how do the changes impact plant safety and reliability?"

Digital worker technologies can potentially help. In late 2018, EPRI and power plant operators piloted a head-mounted, hands-free device that enables plant workers to discuss issues with remote experts. A computer with a micro-display on an articulated arm is attached to a standard hard hat (see photo). When the micro-display is positioned about one inch from the user's eye, it has the appearance of a midsize tablet held at arm's length. The device can be worn with safety glasses.

A plant worker wearing the device can video-chat with an expert while sharing his field of view. The expert can make annotations on the display and send documents, videos, and other information to assist the worker in operations and maintenance tasks. Augmented reality on the display enables the user to enter maintenance data and document completion of procedures.

As part of an EPRI pilot study in 2018, an operator at East Kentucky Power Cooperative uses the head-mounted micro-display to scan a QR code on a valve, confirming that he is looking at the correct component. Photo courtesy of East Kentucky Power Cooperative.

EPRI successfully demonstrated all these capabilities at East Kentucky Power Cooperative's John Sherman Cooper fossil plant. Another demonstration is underway at a biomass plant in Canada.

EPRI plans to examine additional digital approaches that can reduce face-to-face interaction during the pandemic. "How can you use virtual reality to train control room workers at home? How can you use mobile inventory queries and part ordering to reduce exposure for staff who work in equipment storerooms?" said Coffey. "These are the types of questions that we want to look at."

EPRI's Coffey continues to facilitate sharing of experiences and lessons among utilities, with the focus shifting to safely transitioning plant employees back to normal operations.

KEY EPRI TECHNICAL EXPERTS

Dwayne Coffey

EPRI Leads Global Energy R&D for a Post-Pandemic Future

Virtually every energy company on the planet is wrestling with how to best meet customers' energy needs during the pandemic and prepare for an uncertain future. This uncommon level of industry alignment presents a unique opportunity to benefit from EPRI collaboration.

EPRI has worked with thousands of utility staff with expertise in generation, transmission and distribution, the environment, and end-use customers to identify the need for and scope of four key research areas to address near- and long-term pandemic challenges:

- Building a more resilient and flexible grid
- Ensuring employee health and safety
- Meeting customers' changing energy needs
- Creating a cleaner energy future

Learn more about EPRI's COVID-19 R&D

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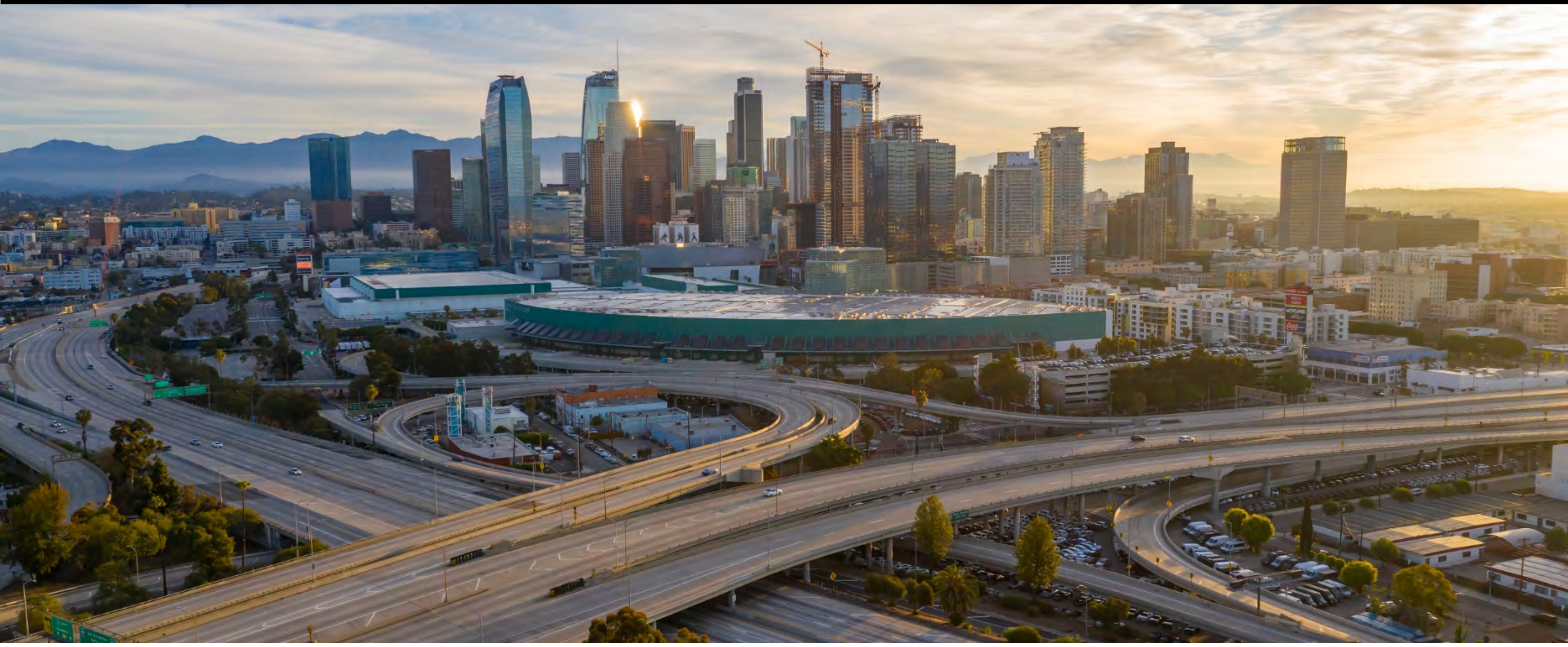

What Can Cleaner Air During the Pandemic Reveal About the Future Electric Power System?

The pandemic offers a unique opportunity to examine how potential future changes in the energy system can improve air quality and health

By Michael Matz

In the months following the onset of the coronavirus pandemic, there has been significant media coverage of reductions in urban air pollution. Numerous researchers have supported this observation with air quality data. For example, National Aeronautics and Space Administration (NASA) satellite data indicate that in March 2020, nitrogen dioxide (NO_2) levels in Northeast U.S. urban areas were 30% lower than in March during the previous five years.

"NO_2 is one of the easiest air pollutants to monitor from space and is a good indicator of fossil fuel combustion in vehicles and power plants," said Bryan Duncan, an atmospheric scientist at NASA. "Researchers may be able to use NO_2 levels to track the pandemic's impacts on carbon dioxide levels, because the two pollutants are typically emitted together."

Duncan was one of several air quality experts presenting at a recent EPRI-facilitated webcast for electric power industry stakeholders on the pandemic's air quality impacts. Nearly 150 utility staff attended. It is one of an extensive series of EPRI webcasts aimed at sharing pandemic-related experiences, knowledge, and insights relevant to the power industry.

According to Melissa Lunden, chief scientist at Aclima, an analysis of air quality data revealed dramatic reductions in several air pollutants in the San Francisco Bay Area during the last two weeks of March 2020 relative to the same period in the previous three years:

- Carbon Monoxide: -15%
- Fine particulate matter (also known as $PM_{2.5}$): -30%
- NO_2: -25%
- Black carbon: -39%

These remarkable numbers prompt intriguing research questions with important implications for the power industry's future: To what extent have broad societal changes during the pandemic—such as reduced use of gasoline-powered vehicles, closure of commercial and industrial facilities, and changes to electricity demand—reduced emissions of air pollutants, and what are the resulting health benefits? How can the answer to that question help researchers forecast air quality and health improvements as a result of widespread deployment of renewable energy and electric vehicles in the coming years?

"This period offers a unique opportunity to examine how potential future changes in the energy system can improve air quality and health," said Eladio Knipping, an EPRI expert on air quality and atmospheric modeling. "It's a real-world, real-time experiment."

EPRI is launching research to investigate how the pandemic has impacted emissions and air quality. EPRI will quantify air pollutant contributions from the transportation, power generation, and industrial sectors before and during the pandemic. According to EPRI's Knipping, the analysis will use receptor modeling and artificial intelligence techniques, drawing on data from existing networks of air quality monitoring stations across the United States.

Researchers also will evaluate meteorological data to remove the effects of weather on air pollutant concentrations. This is an important step because rainfall, temperature, wind, and other weather factors can significantly affect concentrations.

"While reducing emissions is the only way to reach our clean air goals, pollutant concentrations can fluctuate by 90% or more from day to day as a result of weather even when emissions remain constant," said Scott Epstein, who leads the Air Quality Assessment Group at the South Coast Air Quality Management District in Southern California.

"Understanding the drivers of improved air quality during this pandemic can help us predict emissions reductions in the future energy system," said Knipping. "These insights can inform utilities' electrification strategies."

A subsequent research phase will characterize the health benefits associated with reduced air pollution.

EPRI Leads Global Energy R&D for a Post-Pandemic Future

Virtually every energy company on the planet is wrestling with how to best meet customers' energy needs during the pandemic and prepare for an uncertain future. This uncommon level of industry alignment presents a unique opportunity to benefit from EPRI collaboration.

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Learn more about EPRI's COVID-19 R&D

KEY EPRI TECHNICAL EXPERTS

Eladio Knipping, Annette Rohr

Solar After Sunset

EPRI launched a strategic initiative to guide EPRI research on end-of-life issues for solar and wind generation as well as battery energy storage

By Brent Barker

The year is 2040. The Richardson family trades in their aging rooftop solar photovoltaic (PV) system for a more advanced version that comes with a manufacturer's guarantee to recycle 95% of the components. The contractor ships the 2025-vintage, crystalline silicon modules to the local outlet of the National Solar Photovoltaic Recycling Network established by federal regulation in 2025. PV recycling is profitable now, enabled by solar modules' standardized frame-and-sleeve construction along with advanced technology for material recovery and purification.

At the recycling facility, robots place the modules on a conveyor belt where a laser cuts the weather-tight adhesive seal holding the aluminum frames together. The robots carefully open the frames like a book and remove the thin sleeves of crystalline silicon, placing them on another conveyor to a silicon processing station. The frames—which include top and bottom cover glass,junction boxes, and electrical connections—are placed on a third conveyor, where they are washed, flash-dried, packed, and shipped back to the module manufacturer for reuse.

At the silicon processing station, a chemical bath removes specialty metals such as silver and copper. Machines slice and grind the silicon wafers, and thermal and chemical processes purify and recrystallize the silicon. Robots pack the recovered silicon and ship it to the manufacturer for use in new modules.

This scenario underscores a particular reality about solar PV today: Accelerating deployment of PV foreshadows growth of waste. The International Renewable Energy Agency projects that PV module waste volume will rise from negligible levels today to as much as 78 million metric tons in 2050. That's equivalent to about 12 million dumpsters of waste. Despite this projection, the infrastructure needed for large-scale recycling has not yet reached the drawing board.

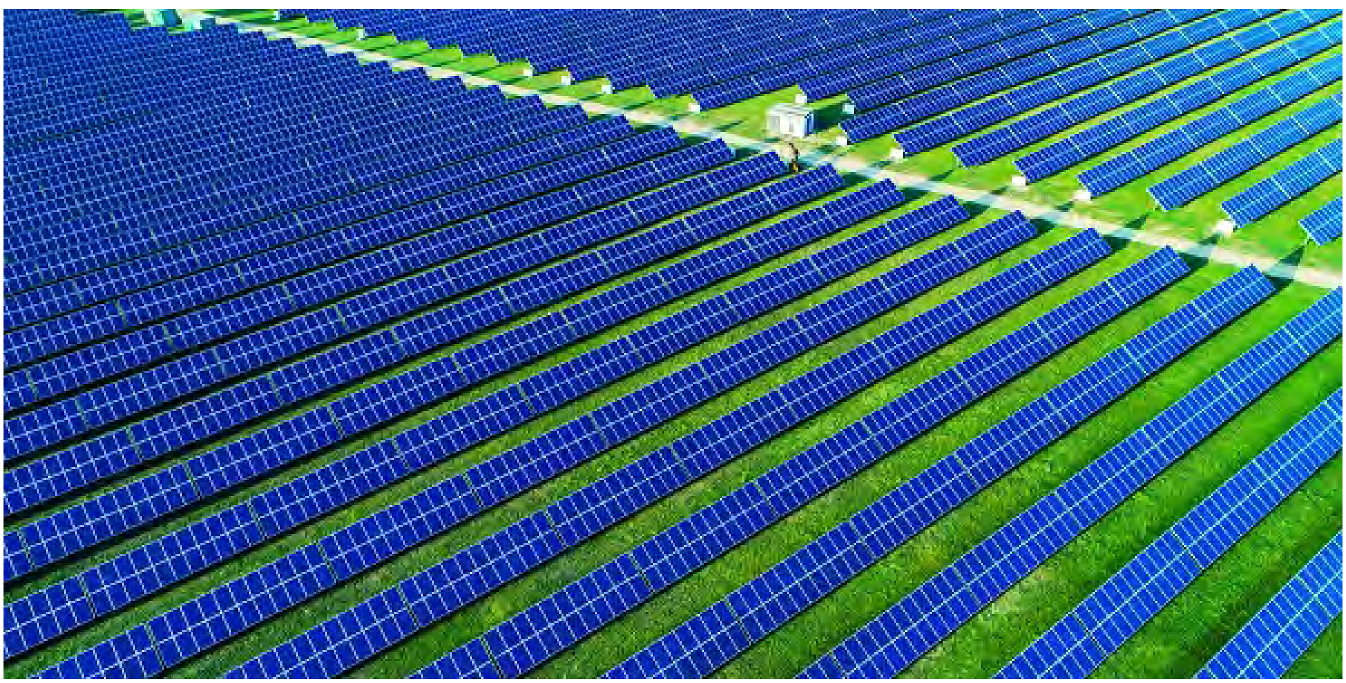
The changing structure and composition of modules make cost-effective recycling a moving target. To cut costs, manufacturers are making modules thinner and are using less valuable materials. This reduces the value of materials that can be recovered.

"Developing the infrastructure and technology for collection systems and recycling processes will take years," said EPRI Principal Technical Leader Cara Libby. "As module designs and compositions change, we need to adapt and develop processes that can recover high-value materials from the latest modules—such as silver, copper, and high-purity silicon. Manufacturers should consider designing modules that are more easily separable into materials and parts."

"When PV modules are disposed of in landfills, they have the potential to break open and release toxic substances into soil and groundwater," said EPRI Technical Executive Stephanie Shaw. "A dynamic, cost-effective recycling industry can reduce landfill disposal, address toxicity concerns, promote reuse of critical resources such as silver, and limit mineral extraction."

The European Union has taken some initial important steps to build a recycling infrastructure. Under the European Waste Electrical and Electronic Equipment directive, producers are responsible for take-back and recycling of modules. More than 40 recyclers around the world, mostly in Europe, claim to process PV modules or subcomponents, such as frames and junction boxes.

In the United States, there are no federal regulations for PV recycling, and most modules are disposed of in landfills and hazardous waste sites. This is driven by economics. An EPRI study indicates that the cost to recycle a module today ranges from $10 to $30 (not including transportation) while the cost to dispose of a module in a local landfill is less than $3.



The International Renewable Energy Agency projects that PV module waste volume will rise to as much as 78 million metric tons in 2050.

PV RECYCLING: STATE OF THE TECHNOLOGY

Recent EPRI technology scouting identified novel mechanical, optical, chemical, and thermal recycling processes at various R&D stages. Recovering high-purity silicon, silver, and copper can dramatically increase the salvage value of a module. EPRI found that many delamination and separation processes aim to keep the front glass intact. This increases the salvage value of the glass and potentially improves the recovery of metals and semiconductor material, but may not be practical for thinner module designs or if the glass is already broken.

Promising methods to improve the yield and quality of recovered materials include leaching, filtration, melting, and electrowinning. Another active research area is automating frame removal.

PV PLANTS: REPOWER OR DECOMMISSION?

As electric utilities own more PV plants, they will increasingly need to consider end-of-life options, which include repowering and decommissioning. Numerous factors drive this decision, including a plant's performance, safety, and the availability of replacement parts and higher efficiency modules. In some cases, plant owners determine that repowering is cost-effective, replace underperforming modules with new ones, and implement associated plant upgrades. A utility may opt for decommissioning based on an assessment of its generation portfolio.

The electric power industry needs decision-support tools that can estimate decommissioning and repowering costs, including end-of-life component recycling. EPRI is considering developing such a tool, which would involve gathering robust data on decommissioning and repowering costs and salvage value.

In 2017, EPRI estimated decommissioning costs for a representative 11-megawatt PV plant at $69 per kilowatt (dc), assuming modules' disposal in a non-hazardous landfill. Dismantling labor was the biggest cost. Recovering and selling steel and copper reduced total cost by 25%. Further savings may be possible by recovering inverters and other electrical components and by selling modules that can be safely reused. If modules were assumed to be recycled, decommissioning costs ranged from $95 to $153 per kilowatt (dc).

There are many ways to repower older PV plants, with a range of cost-effectiveness. EPRI is modeling and testing various repowering scenarios at the Solar Technology Acceleration Center (SolarTAC) in Aurora, Colorado.

"Repowering could mean swapping out one or more underperforming modules in a string or in multiple strings—or replacing megawatts of capacity in a section of a plant that has been damaged by severe weather," said Libby. "Our modeling and field testing can inform how to select replacement modules and how to reconfigure arrays to maximize performance. For example, our modeling suggests that grouping new modules in dedicated strings offers better performance than replacing individual modules in strings throughout a plant. This is because new modules typically have higher power ratings."

A STRATEGIC RECYCLING INITIATIVE

Solar is not the only rapidly growing technology that raises end-of-life concerns. In 2019, EPRI launched a strategic initiative to guide existing EPRI research on end-of-life issues for solar and wind generation as well as battery energy storage. Activities of the initiative include:

- Developing relationships with diverse stakeholders, including government agencies, researchers, technology developers, and recyclers
- Identifying research gaps and promising reuse and recycling technologies
- Creating roadmaps for long-term research
- Tracking and informing policies and regulations
- Developing summary communications for utilities

Various EPRI programs will continue to evaluate technologies and develop information and tools for utilities.

"Our objective is to get ahead of the end-of-life issues that will be hitting producers of solar PV modules, wind turbine blades, and lithium ion batteries—three rapidly expanding energy technologies," said EPRI Technical Executive Ken Ladwig. "We want to conduct and gather research that can identify technologies and inform public policy and regulations."

While these technologies are made of different materials, they are increasingly deployed as integrated systems. Project economics can often be improved by deploying battery storage along with solar and wind. A comprehensive understanding of future recycling needs is therefore essential.

"Our job is to spur technical development for recycling PV, wind, and batteries—which we expect to play a central role in the future energy system," said Shaw. "We are shining a light on end-of-life concerns that can no longer be ignored in the rush to advance performance. Recycling is a next frontier for these technologies."

KEY EPRI TECHNICAL EXPERTS

Stephanie Shaw, Ken Ladwig, Cara Libby, Brittany Westlake

Recycling Batteries and Wind Turbine Blades

Surging electric vehicle (EV) demand has accelerated technology development of lithium ion batteries, driving down battery pack prices from $577 to $176 per kilowatt-hour between 2014 and 2018. With these cost declines, lithium ion technology has become dominant in the market for stationary, grid-scale batteries. Yet there is only one facility in the United States (Retriev Technologies in Lancaster, Ohio) that recycles utility-scale lithium ion batteries.

"Most analysis of battery recycling focuses on the EV market," said EPRI Technical Leader Brittany Westlake. "However, the chemistries and battery shapes can be quite different for stationary deployment, which can complicate standardized recycling processes. There are not 31 flavors like ice cream, but close."

EPRI estimates that the cost to disassemble, transport, and dispose of modules from a 1 megawatt lithium ion battery system ranges from $52,000 to $151,000, depending on chemistry. U.S. Department of Energy and other researchers are investigating technologies with potential to advance battery recycling. Pyrometallurgy uses high temperatures to extract and recover valuable metals while hydrometallurgy uses aqueous solutions to leach out metals for recovery.

EPRI is engaged with federal efforts to advance battery recycling, including the ReCell Center at Argonne National Laboratory. "A major goal of the center is to recover a battery's cathodes intact," said EPRI Technical Executive Stephanie Shaw. "This can potentially provide twice the value compared to other recycling approaches."

Wind turbine blades are typically disposed of in landfills. Solutions to growing wind turbine waste likely will center on developing blade materials that can be easily recycled or remolded into new blades. One promising area is thermoplastic materials, which soften when heated and then harden into new molds under controlled cooling. Such materials also offer the potential for lower cost welds for in-service blades. The National Renewable Energy Laboratory is developing blade prototypes made with thermoplastic materials.

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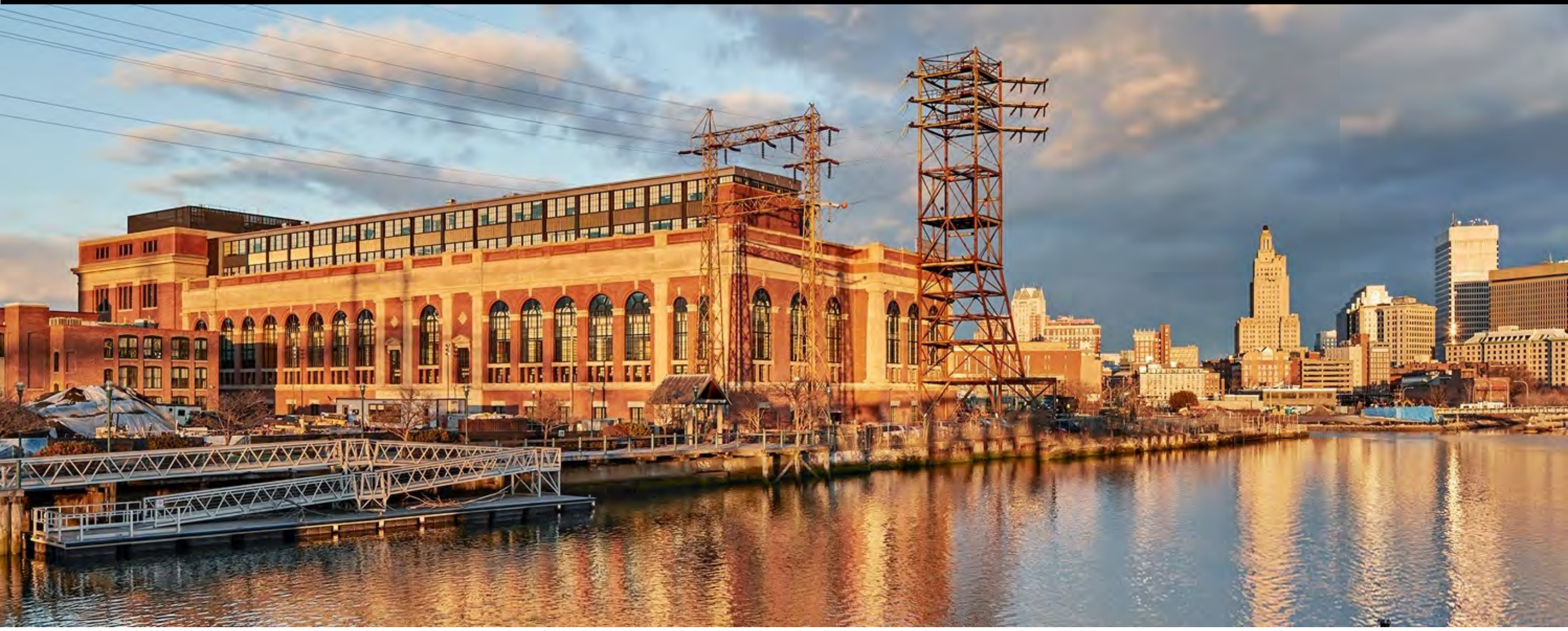


A Second Life

With coal plant retirements at an historic high, EPRI works with power companies to find productive new uses

By Chris Warren

Commissioned in 1948, the 100-megawatt Seaholm Power Plant was an economic engine for Austin, Texas, providing electricity for all the city's residents in the 1950s. As Austin grew, new power plants were built to supplement Seaholm, which stopped operating in the late 1980s. By 1992, the plant's 8-acre site was overgrown with weeds, and, in the late 1990s, there was serious talk of demolishing the deteriorating building.

Today the Seaholm Plant has emerged as a hub for redevelopment in one of the country's most dynamic cities. Taking advantage of its location near Lady Bird Lake and Austin's thriving entertainment district, Seaholm has been redeveloped into a mixture of 280 apartments and condos, 1.5 acres of green space for events and performances, and 130,000 square feet of commercial space occupied by local businesses, a Trader Joe's grocery store, and the healthcare company, Athenahealth.

Though redevelopment required significant upgrades and modifications to serve 21st century urban residents and businesses, the Art Moderne power plant retains its aesthetic—earning a prestigious Driehaus award from the National Trust for Historic Preservation.

MORE PLANTS TO REPURPOSE

Among power plants, Seaholm is one of many examples of innovative repurposing. South Street Station, a Classical Revival–style coal plant that provided electricity to Providence, Rhode Island, is now home to administrative offices for Brown University and a nursing school operated by the University of Rhode Island and Rhode Island College. The Ottawa Power Station, which operated for more than 50 years in Lansing, Michigan, is now the corporate headquarters of the Accident Fund Insurance Company of America. The redesigned and modernized Art Deco plant earned a place on the National Register of Historic Places as well as LEED (Leadership in Energy and Environmental Design) certification.

The redeveloped site of the Seaholm Plant in Austin, Texas. Photo courtesy of Southwest Strategies Group. This is the redeveloped site of South Street Station in Providence, Rhode Island. ©Tsoi Kobus Design.

As the pace quickens for closing coal power plants, the need grows to find new uses for these facilities. The U.S. Energy Information Agency expected coal use in 2018 to fall to its lowest level since 1979—44% below its peak in 2007. In total, 200 coal plants totaling 102 gigawatts ceased operations between 2000 and 2016. S&P Global Market Intelligence projects an additional 28 gigawatts of U.S. coal plants to retire between 2019 and 2023.

SHARING KNOWLEDGE AND EXPERIENCES

Utilities face complex decisions regarding the buildings, extensive infrastructure, and land that make up a typical coal plant. As part of a new EPRI initiative, utilities are sharing their experience and exploring various options for their retiring coal plants. A recent EPRI white paper describes a comprehensive process for moving such efforts forward.

"The closures are coming at a rate nobody has seen before, and collaboration is a necessity," said EPRI Senior Technical Leader Lea Millet, who is leading the initiative. "We facilitate collaboration and make sure people are aware of the options."

Millet is uniquely suited to lead this work. Before joining EPRI, she spent more than 12 years working in environmental permitting and compliance, site remediation, and plant decommissioning at a southern U.S. electric and gas utility. Millet recently took over EPRI's power plant decommissioning program, which provides power companies with a forum for sharing information through webinars and workshops. As the result of member input, the program is now focusing more on plant redevelopment.

In February 2020, an EPRI workshop on power plant redevelopment provided an update on Seaholm and other projects. Utility staff attending the event learned about approaches to planning and implementing decommissioning and redevelopment. They indicated interest in future work, such as the development of a database of information on how utilities have repurposed plants.

"EPRI provides a valuable networking resource for utilities across the country that are anticipating or working through the decommissioning process," said Jeff Battaglia, decommissioning manager at Consumers Energy.

ATTRACTIVE ASSETS

The repurposed sites in Austin, Providence, and Lansing point to the significant potential of retired plants in desirable urban locations—and with historically significant structures. Rural plants also offer potential, though the most viable uses may differ from those in urban areas. The best path forward varies from site to site.

There are some attributes common among coal plants that make them attractive for industrial and commercial reuse. Most are located on navigable waterways. Many are outfitted with railway lines and equipment used for unloading coal—infrastructure that future manufacturing facilities can use for receiving raw materials and shipping finished goods to market.

Coal plants have already been through the rigorous permitting process required to load, unload, and ship materials and goods on waterways. “It’s a major undertaking to find a new property and go through the whole permitting process with the Army Corps of Engineers,” said Millet.

Coal plants have significant power infrastructure. “There is typically a substation on-site or nearby, and the transformers on-site are heavy duty and reliable,” said Houston Roberts, a partner with North Carolina–based Forsite Development, a company that acquires and redevelops large industrial plants and has redeveloped five coal plants. “Groups needing a lot of power such as data centers, aluminum smelters, and other big manufacturers could take advantage of the strong interconnection.”

SUPPORT FROM PUBLIC AGENCIES

Utilities exploring new uses for coal plants can take advantage of expertise and support from government agencies. “There are a lot of economic development agencies and funding streams, both federal and state, available to help with the planning,” said Millet. For example, the Pennsylvania Department of Community and Economic Development (DCED) received a federal grant to identify new uses for the state’s retiring coal plants.

The first beneficiary of DCED’s assistance was FirstEnergy’s Mitchell Power Station, a 370-megawatt coal plant near Pittsburgh that closed in 2013. DCED staff worked with FirstEnergy and other stakeholders to develop a redevelopment “playbook.” This analyzed market demand, the site’s physical and environmental assets, repurposing alternatives, the financial feasibility of the alternatives, and implementation.

Because of the site’s rail, river, and road infrastructure, the playbook pinpointed plastics, chemical, and other large manufacturers as ideal new owners—an insight used to focus outreach.

THE CHALLENGES OF REPURPOSING

Redevelopment is not a straightforward process. Forsite’s Houston Roberts says that just getting a site ready for a second life is difficult. He has steered the change of former North Carolina coal plants to a biomass plant burning wood pellets and a power plant fueled by chicken waste. “These are challenging sites, particularly for demolition and environmental remediation,” he said.

Remediation can include addressing asbestos (particularly in plants built before 1970), heavy metals, and coal ash. This work is expensive, and it can be difficult to determine who will pay for it: the utility or the new owner.

For many communities, closing a plant means the loss of jobs and tax revenue that have been counted on for decades. “Our coal plants are highly valued, and closing one might reduce local tax revenue by 40% to 70%,” said Lynn Wilson, the stakeholder engagement manager for Consumers Energy, which has closed several coal plants. The power company recently received approval from Michigan regulators to phase out coal generation entirely by 2040.

Coal plant redevelopment may also come with psychological challenges. “This is an emotional topic,” said Wilson. “Some people have devoted their entire careers to a facility. Sometimes this spans multiple generations.”

Recognizing this emotional aspect, Wilson and her colleagues at Consumers Energy prioritize communication. “We make sure that our major stakeholders in an area never learn about major project developments from the newspaper. If there’s big news, they hear it personally from us first,” said Wilson. “It’s important to keep communication lines open and talk about the plans and timeline for the property.”

To support productive engagement with communities, Consumers Energy has funded studies on future economic uses for sites that are closing. “Those studies come up with recommendations on which industries would be well-suited for particular sites and communities,” said Wilson.

A study that points to specific, tangible uses for retired coal plants can inform those who may believe that power plants are suitable only for generating electricity.

Another potential challenge for repurposing coal plants is the internal dynamics at many utilities. Often, one utility department is responsible for environmental remediation and building demolition, while another is charged with considering redevelopment. “Utilities have people who operate plants while they are in power generation mode and other people who decide that it is going to get closed,” said Millet. “As closure approaches, plant management is transferred to a decommissioning group. A separate real estate or asset management group handles redevelopment.”

Another approach, Millet says, is for senior leadership to establish and fund a repurposing initiative with a mandate to work with all departments across the utility. “Every facility is going to close at some point,” she said. “It’s best to start these conversations early as part of long-term planning, and it’s best to include stakeholders from across the organization. A comprehensive approach is likely to have the most success.”

KEY EPRI TECHNICAL EXPERTS

Lea Millet

EPRI JOURNAL

Ready for Takeoff?

EPRI is assessing the state of electric aviation—from companies and technologies to designs and research gaps

By Chris Warren

The 2019 Paris Air Show—one of the global aviation industry's premier events—was full of hints that the future of air travel increasingly may be electric. One big headline at the event: Massachusetts-based regional carrier Cape Air became the first airline to order battery-powered commercial airplanes. Beginning in 2023, Cape Air will fly nine-passenger electric planes called Alice, unveiled at the Paris Air Show by Israeli manufacturer Eviation. Alice can fly up to 650 miles on a single charge of its lithium ion batteries.

Other aviation news points to the increasing momentum to electrify airplanes. For instance, United Kingdom–based Rolls Royce announced its planned purchase of Siemens' electric and hybrid-electric aerospace propulsion division. France-based Airbus unveiled plans to test hybrid airplanes by 2022. In the United States, NASA is working with industry giants such as Boeing, GE, and United Technologies to develop electric propulsion systems as part of its Advanced Air Transport Technology Project.

SCOUTING AN EMERGING INDUSTRY

These and other such developments are on the radar of EPRI's Technology Innovation (TI) program, which is assessing the state of electric aviation. The program's innovation scouts have catalogued companies developing aircraft, assessed the maturity of their designs and technologies, and identified research gaps that challenge commercialization.

Innovation scouts work to provide electric utilities with a useful understanding of emerging technologies that could impact their operations. Also, they assess how EPRI expertise can help advance commercialization.

Eviation's "Alice" electric airplane. Photo courtesy of Eviation.

"EPRI's role is still to be determined but there are obvious alignments," said Stephen Stella, who manages EPRI's Technology Innovation program. "Electric planes typically require energy storage, and we have that research. There are charging systems, electric propulsion, and power management systems, and we have that research as well. In many areas, we won't need to reinvent the wheel but rather figure out how to adapt existing technologies to new uses."

EPRI's innovation scouts have identified more than 100 companies involved in electric aircraft development. The list includes big manufacturers such as Boeing and Airbus and small startups such as Ampaire. The rideshare company Uber is investigating the use of small electric aircraft in its business and in 2016 released a white paper about electric aviation.

Some designs are essentially drawings while others are prototypes or demonstration vehicles. The innovation scouts' main takeaway for utilities is that commercially available versions of electric and hybrid airplanes are likely 18 to 24 months away.

LOWER EMISSIONS AND COSTS

According to the non-profit Air Transport Action Group, the global aviation sector produces about 2% of the world's carbon dioxide emissions. Electrifying aviation can lower those emissions significantly. It also can save money.

"Aviation fuel is expensive, and electricity is lower cost across the board. That can make a big difference," said John Halliwell, a technical executive in EPRI's Electric Transportation Group. "The mechanical structures in electric aircraft are likely to be simpler than those in internal combustion engines, so you'd have less maintenance."

Advances in battery technologies also are expected to lower costs for electric aviation. Electric aircraft manufacturer Ampaire claims that a hybrid electric plane could potentially reduce fuel costs by 50% to 70% and maintenance costs by 25% to 50%.

The early focus of technology development is small aircraft—typically those with just one or two seats.

"You can't electrify large planes with today's battery technology because of inadequate energy density," said Halliwell. "At takeoff, jets require megawatts of power, which is why you see some initial large aircraft concepts with battery designs that don't exist yet—and you see hybrid designs that still rely on internal combustion engines."

A UTILITY PERSPECTIVE

According to Halliwell, utilities will need to play an important role in addressing electric aviation's technical challenges. At the top of that list is how to charge batteries. The first electric and hybrid airplanes are expected to be small and to fly in and out of regional airports. While most of these airports will be able to handle the charging requirements, others may need to bolster distribution lines or transformers. As electric airplanes become more common at regional and major airports and require fast charging for quick flight turnarounds, the need for grid upgrades will increase along with the ability to charge and replace onboard batteries quickly.

Halliwell points to the importance of cultivating more discussion among airplane manufacturers and utilities, particularly regarding how aircraft will interface with the electric distribution system. As chair of a committee on energy storage and charging launched by the aerospace standards organization SAE International, Halliwell understands firsthand that the utility perspective is essential in developing electric aviation.

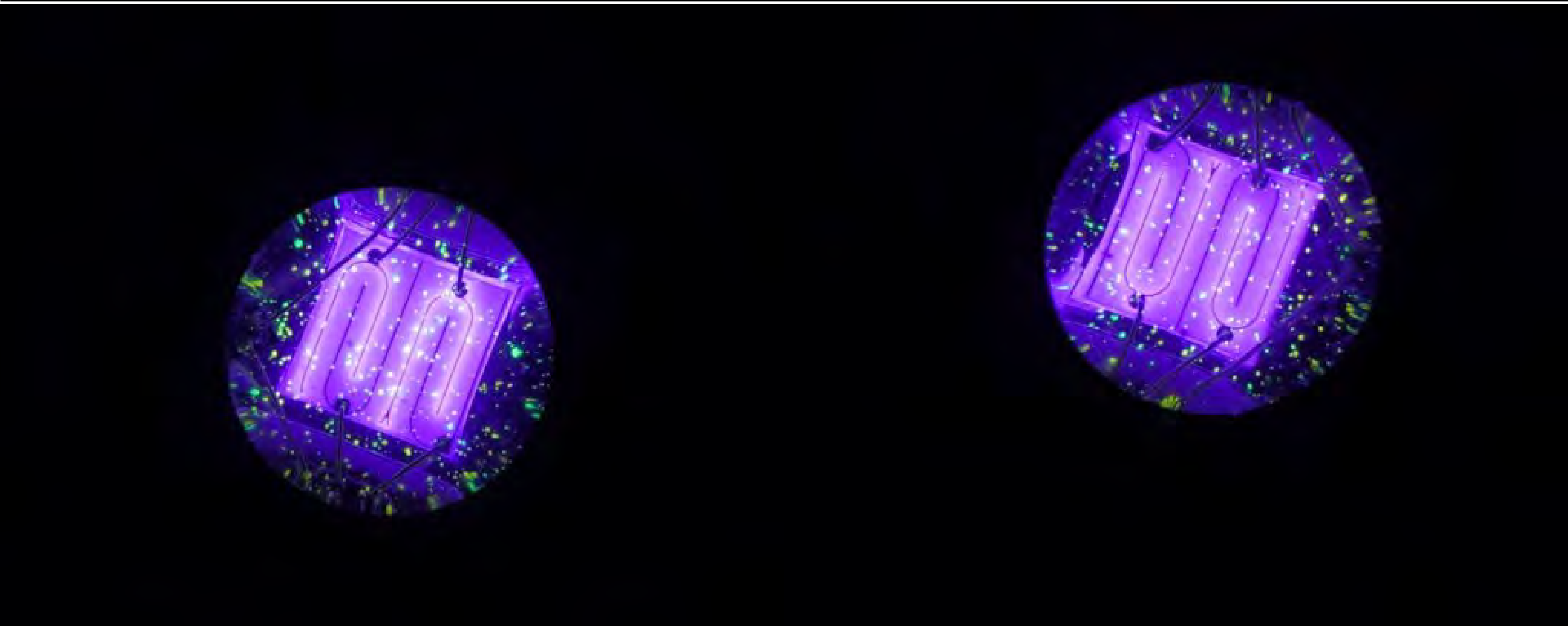
"I was at a meeting examining how much power and charging energy you would need for aircraft and how much it would cost," he said. "The group used the average wholesale rate in the U.S. when they were talking about multi-megawatt charging, but average rates aren't helpful for this sort of economic analysis. Actual costs depend on the amount of power needed, local rate structures, and when the charging takes place. Delivering high power for short durations will generally include a more complex rate structure that includes demand charges."

Halliwell sees a precedent for EPRI's role in electric aviation development. In the early 1990s, EPRI launched the Electric Transportation Infrastructure Working Council, which has fostered collaboration among automakers, regulators, and utilities interested in the development of electric vehicles (EVs). The council serves an important role in informing industry standards for connecting EVs to chargers as well as in electrifying truck stops, ports, and other transportation systems. It continues to meet three times a year to identify and address technical challenges.

"You have to make those connections between aircraft designers and utilities," Halliwell said. "Aircraft designers have to consider and understand the consequences of how they choose to charge an aircraft, including factors like power levels and timing. Those connections help everyone gain a full understanding about how electricity is delivered and what electric aviation needs to succeed."

KEY EPRI TECHNICAL EXPERTS

Stephen Stella, John Halliwell



Questions About Disinfection and Other Technologies to Help Address Pandemic Concerns? Consult EPRI's COVID-19 Resources

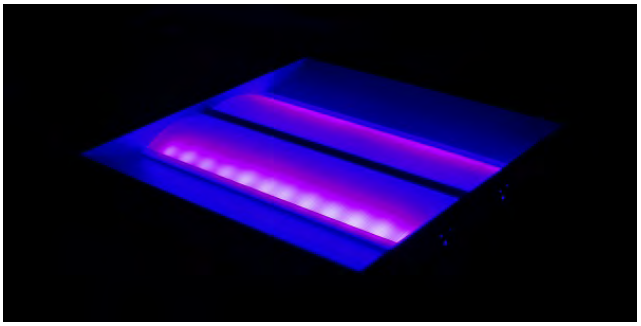
By Michael Matz

During the COVID-19 pandemic, a cross-sector research team at EPRI has developed a series of resources to inform the power industry about various health-related technologies with potential to reduce the spread of infection:

Quick Insight: Light-Based Technologies for Air and Surface Disinfection (April 2020): This technical brief from EPRI's Customer Technologies Program discusses two classes of light-based technologies for air and surface disinfection: ultraviolet (UV) lighting and non-UV LED lighting. UV light disinfection is a well-established technology that has been used in healthcare and other industries for decades. Guidelines and experience from those applications can potentially be applied and adapted in power industry settings. Because high levels of UV light can adversely impact human health, this technology should be used with appropriate protective equipment and processes or in spaces unoccupied by people. Non-UV LED lighting is an emerging technology that uses visible, near-UV light. If implemented in a consistent, appropriate manner, it can potentially be used for disinfection in the presence of people with minimal or no protective equipment. EPRI has launched research to evaluate electric disinfection technologies and applications to help support utilities and their customers during the pandemic.

Disinfecting Control Rooms and Energy Control Centers (April 2020): Produced by EPRI's Plant Engineering Program, this brief discusses the pros and cons of various options for chemical disinfection of surfaces (wipes, sprays, mist applicators) and areas (fogging products, continuously disinfecting surface covers).

Safety and Operational Guidance for Ultraviolet Germicidal Irradiation (April 2020): This brief from EPRI's Plant Engineering Program discusses human safety and operational guidance for UV disinfection devices, considerations for selecting devices, health effects of UV light, relevant standards and exposure limits, and personal protective equipment for use during UV disinfection activities.



Detailed view of LEDs that emit violet disinfecting light with a wavelength of 405 nanometers.

These two photos show two operational modes of a switchable, disinfecting LED fixture. The first photo shows a mode that combines white light and disinfection violet light (with a wavelength of 405 nanometers) and is designed to be used when the space is occupied. The second photo shows a mode that emits only 405-nanometer violet light for stronger disinfection and is meant to be used when the space is not occupied.

Characterization of Ultraviolet-C Sanitizers for Controlled Area and Surface Disinfection (May 2020): Some nuclear and fossil power plant components emit electromagnetic waves with potential to create electromagnetic interference with other equipment and adversely impact plant operations. EPRI's Plant Engineering Program evaluated the electromagnetic emissions of several UV light disinfection devices and assessed the risk of interference. Researchers also evaluated various operational characteristics of the devices.

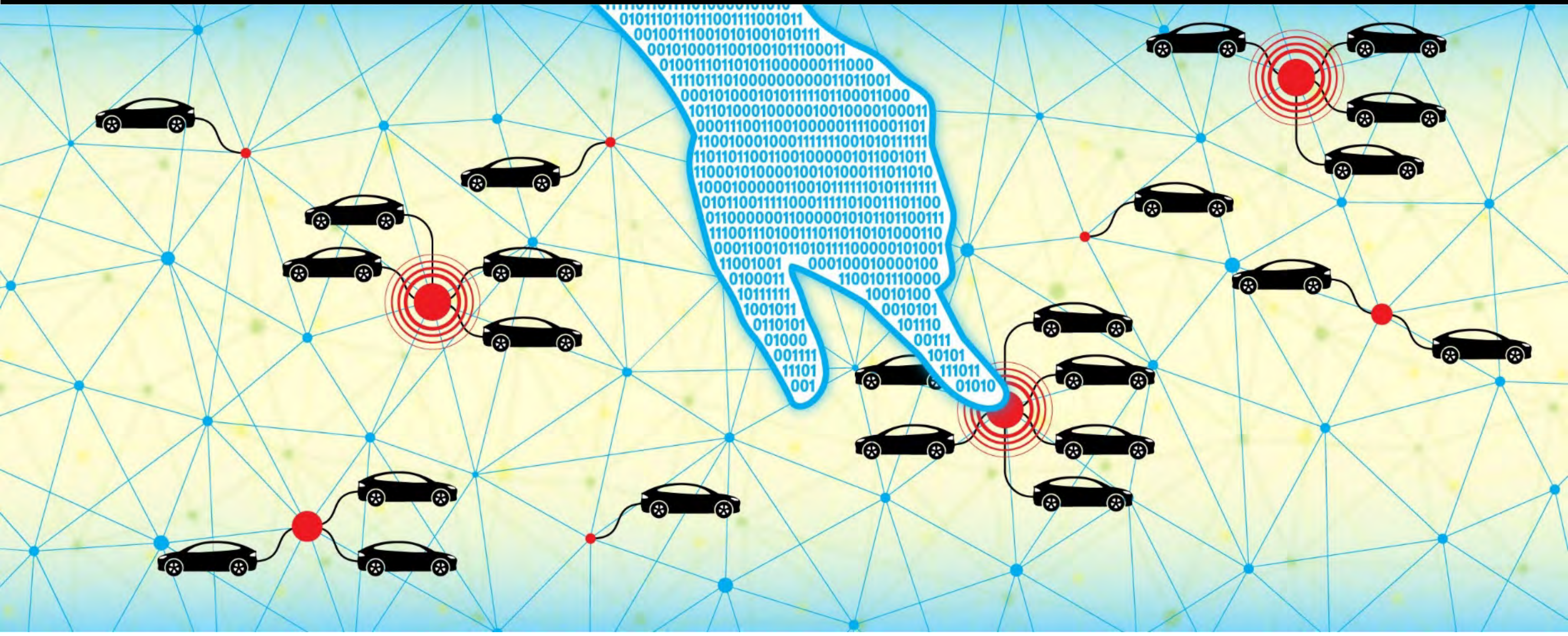
Non-Ultraviolet Disinfection Lighting: Analysis of Power Consumption and Spectral Output (December 2019): In this study, EPRI's Customer Technologies Program analyzed the power consumption and operational costs of non-UV LED light disinfection devices in various settings, such as medical facilities, classrooms, offices, gyms, bathrooms, and kitchens. The study also evaluated the potential energy impacts of the technology's broad deployment.

Facial Thermography Tools to Help Reduce Spread of COVID-19 (April 2020): Across the world, power plants are using facial thermography to help reduce the spread of COVID-19 by detecting elevated skin temperatures. This video, produced by EPRI's Plant Engineering Program, discusses the technology's capabilities as well as best practices and limitations.

Quick Insights: Research Pathways for Building Technologies that Enable Healthier Work and Living Spaces (May 2020): This paper from EPRI's Technology Innovation Program discusses research opportunities to advance understanding of four promising technologies and approaches that may reduce transmission of pathogens in buildings and enhance human comfort and health: non-UV LED lighting for disinfection, cold plasma, high-efficiency dehumidification systems, and passive house design standards.

KEY EPRI TECHNICAL EXPERTS

Mark Woodby, Ron Domitrovic, Sara Mullen-Trento



Spotting the 'Hotspots'

EPRI developed a tool called HotSpotter that utilities can use to pinpoint the most vulnerable customer service transformers

By Chris Warren

As electric vehicle (EV) charging expands in many countries, utilities need tools to identify potential impacts to the distribution grid. Since 2012, EPRI has investigated these impacts.

"We found that the initial impacts of residential charging are not along the distribution power lines or near the substations but at the service transformers that step down the electricity voltage in distribution lines to the level used by customers," said EPRI Senior Technical Executive Arindam Maitra. "Those are the weak spots for residential charging, and the worry is that high EV penetration in certain areas could lead to the transformers overloading."

Building on this finding, EPRI developed a tool it calls *HotSpotter* that utilities can use to pinpoint the most vulnerable customer service transformers. "It identifies 'hotspots' where transformers have the highest probability of overloading, and it indicates power ratings of transformers that could be vulnerable," said Maitra. "This information can help utilities prioritize mitigations."

By analyzing EV adoption rates, charging times and rates, and other EV data, HotSpotter simulates load impacts on a transformer based on its nameplate rating, peak load, the number of customers it serves, and other characteristics.

"HotSpotter can estimate customer-level charging impacts as a result of growing EV adoption and calculate the cost of transformer replacements," said Maitra.

HOTSPOTTER AT WORK IN SACRAMENTO

Sacramento Municipal Utility District (SMUD) used HotSpotter to assess the potential impacts of EV adoption on its distribution system.

"EVs offer economic and environment benefits and can lead to load growth," said SMUD Senior Engineer Deepak Aswani. "We wanted a rigorous understanding of the value of EV adoption, the grid impacts, and how electricity rates could mitigate those impacts."

SMUD developed a tool in-house to model EV adoption and to compare the grid impacts of different charging power levels and times. While the internal tool was helpful, several factors led the SMUD team to use HotSpotter to augment these analyses. Unlike HotSpotter, the SMUD tool wasn't able to model different transformer sizes and number of customers. HotSpotter operates more quickly and can be reconfigured more easily to modify the modeling scenarios.

"SMUD used the HotSpotter tool to more quickly and easily run additional analyses and evaluate how grid impacts vary depending on service transformer sizing, the number of customers associated with each transformer, and EV load shapes," said Dwight MacCurdy, energy research and development project manager at SMUD. "We learned how to strengthen grid reliability and support EVs based on regional differences in our distribution system. HotSpotter is a very versatile, user-friendly, and useful tool for examining EV load impacts."

Findings from HotSpotter simulations and related research with EPRI technical staff include:

Across SMUD's service territory, charging 93,000 additional EVs could result in approximately 1,000 transformer overloads.

Replacing each pole-mounted transformer and pad-mounted transformer would cost $4,700 and $6,000, respectively.

Simulated overloads were concentrated in hotspots: About 50% of the service transformer overloads occurred in distribution feeders associated with 10% of SMUD's substations.

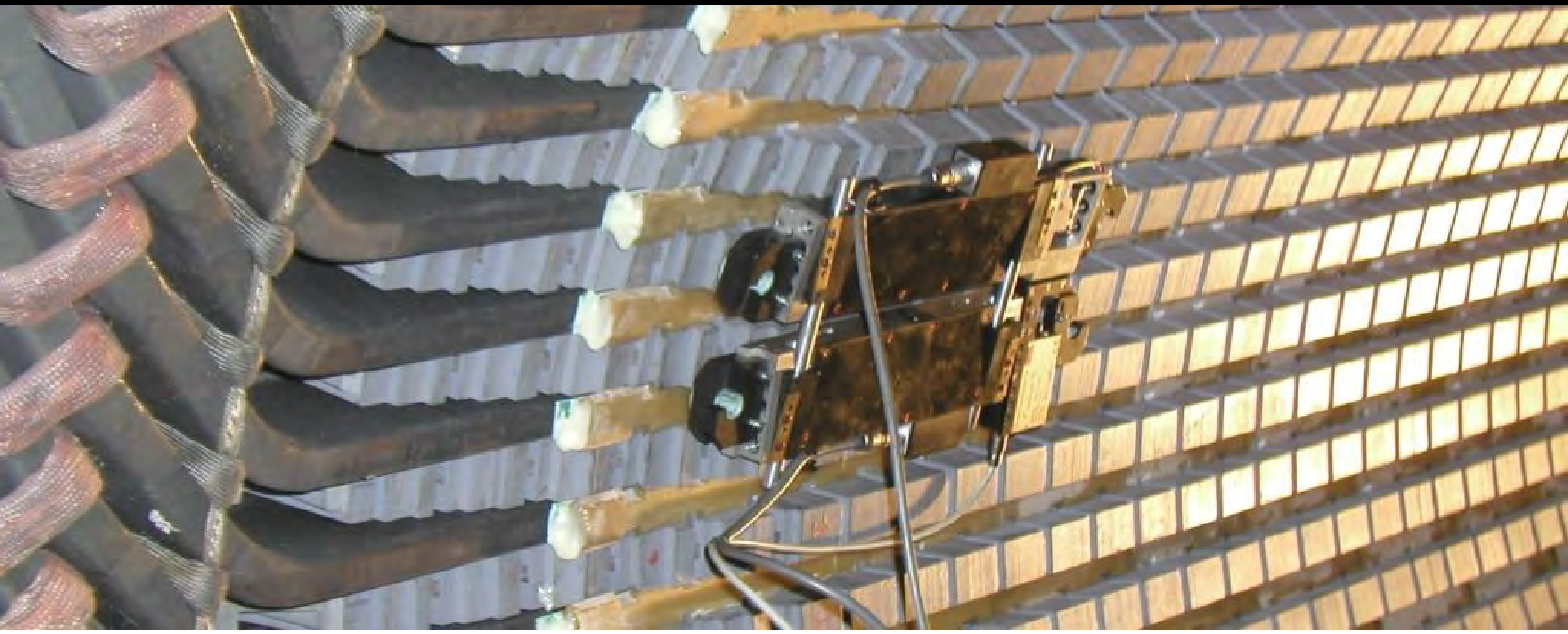
Grid impacts could be mitigated by using time-of-day rates to shift EV charging from late-afternoon peak demand to night, potentially avoiding the need to invest in system upgrades.

"EVs have the potential to reduce the cost of electricity by increasing consumption of lower cost off-peak energy," said Aswani. "The HotSpotter analysis confirmed our internal analysis, demonstrating that the time-of-day rate design can encourage EV drivers to shift charging to off-peak times. This makes our grid more efficient."

SMUD is considering using HotSpotter also to better understand the impacts to its system of large numbers of electrified buses and trucks. "In Sacramento, as in other areas of California, we're seeing more workplace and DC fast charging and adoption of electric school buses, transit buses, and short-haul delivery trucks," he said. "HotSpotter could be a useful tool to evaluate this new frontier of electrification in California."

KEY EPRI TECHNICAL EXPERTS

Arindam Maitra



*C*rawler robot inspecting a generator. Photo courtesy of Iris Power.

Robotics in Power Plants: Getting Smaller, Smarter

According to a recent EPRI study, robotic inspection of generators without removing the rotor offers a cost-effective alternative to rotor removal and inspection

By Tom Shiel

Companies that operate nuclear and fossil fuel power plants know well that it's important to take good care of the turbine-generator. Failures can cost millions of dollars in direct repair expenses and lost generation revenue. Traditionally, detecting certain failure mechanisms has required shutting down the unit and removing the generator rotor for a thorough visual inspection. These inspections are expensive—up to $500,000 for large generators and less for smaller units. Generator rotor removal also has potential risks, such as dropping the rotor or bumping and damaging the stator.

According to a recent EPRI study, robotic inspection of generators without removing the rotor offers a cost-effective alternative to rotor removal and inspection. Based on a survey of more than 30 utilities as well as discussions with major manufacturers Siemens Energy and GE, EPRI found that robotic inspections provide reliable results and cost up to 75% less depending on the generator's size.

"All indications are that robotic inspections yield results equivalent to rotor-out inspections," said EPRI Technical Executive Bill Moore, who led the research. "Power industry acceptance of this approach should continue to trend upward." More than 82% of respondents in the EPRI survey have conducted a robotic inspection on at least one unit in their fleet, and nearly two-thirds reported satisfaction with the results.

The EPRI study reported on attitudes toward robotic inspection among key electric power industry stakeholders. For example, insurance companies often pay for generator repairs and lost revenue associated with forced outages, thereby having a say in how generators are maintained. While they previously were reluctant to accept robotic inspections as equivalent to "rotor-out" inspections, many do now.

The EPRI research also provided an in-depth assessment of the state of the technology. In particular, “crawlers” are the most commonly deployed robot for generator inspections. They typically use “caterpillar” tracks (similar to those on military tanks) to move through a narrow space (known as an *air gap*) between the generator’s rotor and stator, carrying cameras, lights, and various sensors to conduct multiple inspections and tests. The robots connect to a power supply and control hardware through cables and transmit data for processing. To access smaller spaces, inspection technicians may use devices known as *telescopic masts*, which extend thin metal structures equipped with sensors.

Researchers found that robotic inspections on some units face challenges. For example, not all generator air gaps can be accessed by the larger robots, and some generators have additional obstructions that require precise maneuverability that not all robots can provide. Also, unlike rotor-out visual inspections that enable human inspectors to view defects directly at close range, robotic inspections require technicians to interpret camera images, which sometimes distort color and size.

There are nearly a dozen robot models available today. Manufacturers include Siemens Energy, GE, IRIS Power, Brush/Dekra, Mitsubishi-Hitachi, Ansaldo, Toshiba, ABB, and Nova Technology. When EPRI first researched this technology nearly 20 years ago, only three robots were available.

The EPRI study examined the technology’s current capabilities and latest advancements. Over the past few years, robotic inspection technology has advanced rapidly, driven by broader developments in robotics, computers, software, cameras, and lighting. One robot model carries four cameras, and image resolution for cameras on most models rivals the best television technology. Robots for generator inspections are getting smaller, thinner, and more maneuverable.

“The older models of crawler robots are up to 30 millimeters thick,” Moore said. “Now, smaller models are in the range of 12 millimeters. As robots get smaller, more of them can access generators with smaller air gaps. We’re still not able to perform a robotic inspection on 100% of operating generators, but the number we can’t inspect is getting smaller.”

“We make improvements with our robots multiple times a year as new technology becomes available,” said Colleen Crawford, who manages generator service research and development at Siemens Energy. “Each year, the robots can get into smaller spaces in the generators. Digitalization has enabled us to reduce the size of the inspection crew by one-third. We expect to develop even more automated systems.”

Moore predicts that the addition of artificial intelligence (AI) to robotic inspection will enhance results. For example, object recognition software could distinguish between acceptable conditions and anomalies, such as a foreign objects or obstructions.

“At EPRI, we believe AI can lead to further advances in robotic inspection development,” Moore said. “If these robots can automatically distinguish between acceptable and non-acceptable conditions, technicians may not have to continuously observe the robots as they inspect generators.”

Robotic inspection of generators is part of a broader trend of more automated generator monitoring and diagnostics. The ultimate objective for utility owners and technology developers is comprehensive knowledge of generator conditions without rotor removal, saving time and money.

KEY EPRI TECHNICAL EXPERTS

Bill Moore

EPRI JOURNAL

Who Wants to Buy an Electric Vehicle?

An EPRI survey reveals who is interested in buying an electric vehicle and how incentives might help

By Mary Beckman

The U.S. Environmental Protection Agency reports that passenger vehicles contribute about 17% of the greenhouse gas emissions in the United States. Utilities recognize that electric vehicle (EV) adoption can help reduce emissions in their service territories. Indeed, in setting greenhouse gas reduction targets, utilities are factoring electrified transportation in their strategies.

However, with scarce data on consumer interest in EVs, it's hard for utilities to know how best to encourage their customers to purchase them.

"Utilities want more of their customers to buy EVs, but they don't know where to start," said EPRI Data Scientist Jamie Dunckley.

With funding from eight utilities, Dunckley's team designed a survey to determine which demographic groups are most interested in EVs and which incentives might entice people to buy them. They surveyed 3,200 utility customers planning to buy a new vehicle within the next 5 years, and about 35% said they would never purchase an EV, regardless of financial incentives or other circumstances.

"For these people, we could have offered a $10,000 rebate, and they were not going to get an EV," said Dunckley.

About 16% said they would buy EVs in any circumstances—even if EVs were more expensive or local charging infrastructure was sparse.

That left about 50% who said they could be convinced to purchase an EV given the right conditions. Respondents in this group are younger, have higher household incomes and more education, or have had some experience with EVs.

"Experience with EVs—even a little experience—is important because there's a lot of misinformation about them," said Dunckley. "People think they don't have as much acceleration power as a conventional vehicle, but in reality they have more power and the power is instant. Being in an EV dispels those myths, so people who have experienced one are much more likely to consider a purchase."

This underscores the value of an EV test drive. For example, Drive Electric Northern Colorado found that the number of people who consider themselves "likely" or "very likely" to purchase an EV increases by 15% after test drives. "Just getting people in the seats really works," said Dunckley.

The survey found that people with higher incomes are more likely to consider a battery-powered EV, but there was not a correlation between high income and interest in plug-in hybrids—possibly because plug-in hybrids are generally more affordable.

The most effective incentives depended on the incentive levels and the region. In low-traffic regions, for example, a $300 discount on an EV purchase price may be more effective than free carpool lane access. The opposite may be true in high-traffic regions. Free parking was more appealing in urban areas than in rural areas.

"As utilities consider strategies to encourage EV ownership, they need to take regional differences into account," said Dunckley. "Offering an incentive that addresses a pain point in a region is a good place to start."

Women were more likely than men to respond favorably to perks such as free parking, carpool lane access, and cheaper electricity. Incentives had more impact on customers who had no experience with EVs, suggesting that skepticism among EV novices can be overcome with more cost-effective options.

Dunckley says that utilities can use the survey as a starting point when developing strategies to encourage EV adoption. With 50% of new car buyers open to the idea, utilities may have a good opportunity to engage with their customers.

KEY EPRI TECHNICAL EXPERTS

Jamie Dunckley

During the COVID-19 lockdown in New York City, closures in the commercial sector drove significant reductions in electricity demand.

Despite Big Demand Swings, Grid Operators Have Kept the Power on During the Pandemic

During the COVID-19 pandemic, nearly all grid operators around the world have successfully managed substantial changes in electricity demand

By Michael Matz

Consider this thought experiment: It's peak load on a hot summer day in Pennsylvania, with generators operating at near capacity to serve more than 31 gigawatts of demand. The state's electricity demand suddenly drops to nearly zero and then returns to 31 gigawatts several minutes later. How would grid operators handle this hypothetical scenario? In India earlier this year, this was more than a thought exercise. In a televised address on April 3, Indian Prime Minister Narendra Modi asked Indians to switch off their lights and illuminate candles for nine minutes at 9 p.m. on April 5 as a show of national solidarity during the COVID-19 pandemic.

Recognizing that a large, swift reduction and recovery in electricity demand could threaten the reliability of electricity supply, India's grid operators spent the next two days preparing for the event. They ramped down India's coal-fired power plants and ramped up hydropower plants to full capacity before the event, with the rationale that hydropower output could be adjusted much more quickly during a sudden demand swing. As Indians began turning off their lights at 9 p.m., operators relied on the flexibility of the generation fleet to ride through the event. Despite the event's unpredictability and scale, no major outages occurred.

India is not alone. During the COVID-19 pandemic, nearly all grid operators around the world have successfully managed substantial—albeit less severe—changes in electricity demand. Between March and May, operators in the United States, Europe, the Middle East, Australia, and Latin America shared their demand data with EPRI. Based on this information, EPRI has monitored and analyzed trends in grid operations and shared the results with the global power industry and other stakeholders.

"In many regions with strict lockdowns, weekday loads suddenly looked like weekend loads, and operators quickly shifted to running the grid as they would during the weekend," said Eamonn Lannoye, an EPRI expert on grid operations and markets. "Weekends also had lower demand than normal, often looking like holiday weekends."

During lockdowns, demand in New York City, Italy, Spain, India, and China's Hubei province dropped by 20–40%. Closures in the commercial sector drove the reduction in New York City while industrial sector restrictions drove the swings in Italy, Spain, and China.

"For decades, grid operators have planned for a wide range of scenarios so that they have 'wiggle room' to adjust operations during unexpected events," said Lannoye. "They went into this pandemic with the tools, training, and experience to quickly react to big changes in demand and supply. Fortunately, the demand reductions occurred in the spring for the northern hemisphere and the fall for the southern hemisphere. The grid is generally easier to manage during these seasons because the demand peaks are relatively small."

In areas such as California and the United Kingdom, a combination of low demand and high levels of solar and wind production resulted in extremely low net loads and challenging voltage conditions on transmission grids. Operators mitigated these problems by adjusting the amount of power that various generation facilities were feeding into the grid. The California Independent System Operator curtailed solar and wind generation. In the United Kingdom, the National Grid Electricity System Operator created a service that enabled control rooms to curtail production from generation facilities outside of traditional electricity markets.

"Grid operators got a 'fast-forward' glimpse at what typical operations may look like in five to ten years, when very high levels of solar generation are expected to result in considerably lower net loads on the grid," said Lannoye.

A LOOK AHEAD

There were higher residential peaks on some distribution systems last summer, and a possible contributing factor was the increased number of people working at home during the day as a result of the COVID-19 pandemic. "The precise impact of the pandemic is uncertain because there were other potential contributing factors, such as very high temperatures and wildfires," said Lannoye. "EPRI plans to examine this issue more closely."

The pandemic has highlighted how uncertainties can impact energy supply and demand. According to Lannoye, grid operators will increasingly need to integrate risk-based methods to guide dispatch, scheduling of generation, and other aspects of operations.

"Risk-based methods involve building a deeper understanding of the range of possible outcomes in various situations," he said. "They can be used to quantify uncertainties in forecasts of load and solar and wind generation—and to reduce those uncertainties by improving forecast methods."

For several years, EPRI has been working with power companies to develop and test grid operational tools that use risk-based methods. EPRI researchers also are examining how energy resources connected to the distribution grid (such as rooftop solar and electric vehicle batteries) can be used in emergency conditions when the transmission grid needs support in maintaining a balance between demand and supply.

KEY EPRI TECHNICAL EXPERTS

Eamonn Lannoye

Back to School for Nuclear Plant Engineers

Drawing on the latest research, EPRI U has launched 13 new courses on aging management in nuclear plants.

By Chris Warren

Drawing on the latest research, EPRI U has launched 13 new courses on aging management in nuclear plants. Available in several new formats, the courses provide nuclear plant operators, engineers, and technicians with accessible, practical training covering fundamentals of aging management, concrete aging degradation mechanisms, selective leaching, radiation of concrete, and more. As the industry replaces retiring long-term employees, EPRI U's more than 20 aging management courses provide a cost-effective way for the emerging workforce to come up to speed quickly and efficiently.

In the United States, a growing number of nuclear plants seek to extend their operating licenses from 60 to 80 years. "A dozen plants have submitted proposals to the U.S. Nuclear Regulatory Commission to do that, and there are more interested," said EPRI Senior Program Manager Sherry Bernhoft.

To support continued safe, reliable operations to 80 years, plants need rigorous aging management programs. Decades of EPRI research in aging management address such issues as impacts of extended operations on concrete, cabling, and other plant materials and components—with practical applications for plant technicians.

The 13 new courses are either completely new or revised. Collaboration drove the effort to update courses and select new topics and content. "Based on input from nuclear power utilities, we added courses such as radiation of concrete," said EPRI Senior Technical Leader Emma Wong. "We updated our fundamentals of aging management course for U.S. and international students."

With the help of 90 employees at 7 utilities, EPRI piloted the new and revised courses, refining their content based on student feedback. For example, participants said that the courses on aging mechanisms of various materials needed more practical information that can help plant staff identify indications of aging. The result: EPRI created a new course, "Visual Identification of Aging Degradation."

EPRI created concise, user-friendly field guides that plant personnel can download and use to identify signs of plant aging, such as cracks in concrete. These offer accessible alternatives to technical manuals. "Think of it as a little book of phrases that you need to know about aging," said Wong. "It's meant to be a guide that plant staff can keep in their pocket and consult for answers just before performing maintenance and other plant-related tasks."

Some courses are delivered through "distance learning." "That means that the instructor and students are in different locations, and they communicate through a computer portal," said Tina Taylor, senior director for research and development in EPRI's Nuclear sector. "Some people are surprised that you can run a course with this format and still have breakout groups and opportunities for students to ask questions."

In other courses, students travel to an EPRI office for instruction, or EPRI instructors travel to a utility to teach. On-demand computer-based training is available for some courses and is being expanded in 2020. Students' feedback prompted EPRI to divide 8-hour computer-based courses into two 4-hour classes on consecutive days, so that participants can cover both the EPRI training and their regular work in a given day.

One U.S. utility requested on-site delivery of all the revamped aging management courses for the entire staff of a nuclear plant. Participants were a mix of new and experienced engineers, program managers, and contractors, with some attending those materials courses relevant to their jobs and others attending all the courses. The courses spurred productive discussions among employees from different departments, prompting enhanced collaboration.

To provide additional support for nuclear plant technicians, Wong is leading the development of an aging management digital assistant application for mobile devices. "Users will have instant access to a large library of reference component photos and links to documents such as EPRI technical reports," said Wong. "Users can take photos of equipment, and the assistant will analyze them for indications of degradation and provide insights on possible causes along with suggestions for addressing the degradation."

EPRI U: Aging Management Courses

*Fundamentals of Aging Degradation and Management

*Metals Aging Degradation Mechanisms

*Concrete Aging Degradation Mechanisms

*Polymers Aging Degradation Mechanisms

*Protective Coatings Aging Degradation Mechanisms

*Electrical Equipment Degradation Mechanisms

*Selective Leaching Training

*Radiation of Concrete

*Fundamentals of Managing Aging Programs USA

*Fundamentals of Managing Aging Programs International

*Electronic and I&C Equipment Degradation Mechanisms

*Visual Identification of Aging Degradation

*Integrated Life Cycle Management

Low-Voltage Cable Aging Management Training

Cable Aging Management—Visual/Tactile Assessment

Cable Aging—Adverse Environment

Alkali Silica Reaction Introduction Training

Alkali Silica Reaction—Detection and Confirmation

Alkali Silica Reaction—Evaluating and Managing Impacts

Alkali Silica Reaction—Developing an Aging Management Program

*New or updated course

KEY EPRI TECHNICAL EXPERTS

Sherry Bernhoft, Emma Wong, Tina Taylor

Global Nuclear Industry Commits to Building a Culture of Innovation

Delegates at the Global Forum on Innovation for the Future of Nuclear Power called for innovation and action plans in four priority technical areas

By Brent Barker

"The most terrifying thing I saw in orbit was the thin blue line that separates the earth from the dark, black void of space," said Garrett Reisman, senior advisor at SpaceX and former NASA astronaut. "It's our atmosphere, and that fragile line is all we have. It's up to you to save the planet." It was June 2019, and Reisman was speaking to more than 250 senior nuclear power industry leaders gathered from around the world in Gyeongju, South Korea, at the Global Forum on Innovation for the Future of Nuclear Power.

Reisman was issuing a challenge to the nuclear industry: Accelerate innovation addressing global climate change. The forum's delegates took Reisman's challenge to heart. After three rigorous days of brainstorms and discussion, they called for innovation and action plans in four priority technical areas.

FIRST-OF-A-KIND FORUM

"This first-of-a-kind forum issued a call to action. It was not a once-and-done conference," said EPRI Chief Nuclear Officer Neil Wilmshurst. "We designed a high-energy, participatory, collaborative conference focused on action. Our vision was to convene utilities, regulators, manufacturers, and researchers—stakeholders that don't typically meet in one place—identify barriers to innovation, and commit to accelerating the most promising technologies. This was about launching a stronger culture of innovation in the nuclear industry."

"For me, the forum was about driving change through innovation," said Fiona Rayment, executive director of the Nuclear Innovation and Research Office at the United Kingdom's National Nuclear Laboratory (NNL). "And change has to be about the economics of nuclear energy."

Korea Hydro and Nuclear Power (KHNP) hosted the forum and co-organized the event with the International Atomic Energy Agency (IAEA), the Organization for Economic Co-operation and Development's Nuclear Energy Agency (NEA), NNL, and EPRI. IAEA and NEA contributed international perspectives, and NNL and EPRI research perspectives.

FOSTERING A CULTURE OF INNOVATION

A central theme of the forum was that the success of the nuclear industry requires a much stronger culture of innovation integrated into every aspect of business. Participants reached consensus that this requires executives to shape a clear vision and lead with actions that enable innovation. It also requires that professionals with diverse roles, experience, and backgrounds engage and share information and experience with stakeholders across the nuclear industry and in other industries.

"You can't measure innovation with return on investment," said Wilmshurst. "Innovation is key to extending nuclear power's vitality and longevity so that this carbon-free energy source is available to meet the global climate challenge."

Accounting for about one-fifth of participants, young professionals served important roles in the forum, including chairing sessions and discussions.

"Usually at industry conferences, the younger, less experienced professionals are expected to play a smaller participatory role," said Rayment. "Not here."

"The innovation we're seeking is not for the older generation," said Wilmshurst. "It's to enable the older generation to hand off a healthy, vibrant industry to early career professionals. We gave them an opportunity to influence their future."

PERSPECTIVES FROM INSIDE AND OUTSIDE THE NUCLEAR INDUSTRY

On the first day, representatives from industries such as aerospace (SpaceX), pharmaceuticals (RenaSci), and telecommunications (SK Telecom) shared experience and insights based on their changes that enabled innovation. One example cited: Global pharmaceutical companies set up small, nimble satellite companies that innovated and handed their innovations back to the parent company. SpaceX emerged after NASA shifted its emphasis from innovation to safety following the 2003 Columbia space shuttle disaster.

"SpaceX stepped in with a culture of trying new things," said Wilmshurst. "They hired people who didn't know what was impossible. The upshot was that SpaceX is now a leader in the satellite launch business."

Invited stakeholders examined barriers and successful examples of innovation in nuclear power. A roundtable discussion for regulatory leaders explored improvements that can facilitate innovation.

"Regulators are key to our success," said Rayment. "We must engage our regulators early in the innovation process or we end up with significant iterations on technology development—which eat up time and money." Rayment suggested that regulators around the world could collaborate to examine best practices and harmonize regulations so that each country doesn't need to start from scratch in the regulation of new technologies.

Forum delegates participated in group discussions to identify and prioritize four innovations and identify actions to address barriers to their deployment in the nuclear power sector:

- Artificial intelligence and machine learning to improve plant performance and reduce operations and maintenance costs
- Innovative frameworks for industrywide sharing of non-proprietary R&D and operations and maintenance data

- Digital twin technologies that recreate nuclear components, systems, processes, and entire plants in computer models to reduce costs and improve performance and training
- Advanced manufacturing technologies, such as powder metallurgy, electron beam welding, and 3-D printing of components

ACTIONS TO ACCELERATE DEPLOYMENT OF INNOVATIONS

Through a new "Global Forum Collaboration Network," nuclear industry stakeholders can meet regularly and collaborate to accelerate deployment of innovation at nuclear plants, with focus on the four priorities.

Wilmshurst discussed key forum insights as part of a speaking engagement at the annual leadership meeting of the World Association of Nuclear Operators (WANO), which brings together nearly all the world's nuclear power executives. He also spoke at the 2019 Innovation for Cool Earth Forum, a conference initiated by Japan's Prime Minister Shinzo Abe. Rayment chaired a panel on innovation at the American Nuclear Society's 2019 Winter Meeting and Expo, and panelists highlighted the forum's priorities.

FREEDOM TO FAIL

Among the forum's key conclusions is the importance of accepting risk and failure. Historically, fear of failure has restricted innovation in nuclear power. Successful innovation requires taking risks, provided that the potential consequences are manageable. Delegates agreed that a "freedom to fail" mindset needs to be embedded in nuclear power companies.

"As an R&D organization, EPRI understands that some things require a leap of faith—and that sometimes you have to take a bit of risk," said Rayment. "EPRI understands the utilities, the technology developers, the need for innovation, and the market for innovation. I expect EPRI to be front-and-center to help the industry do something fundamentally different."

"Success is not final, and failure is not fatal," said Wilmshurst. "It is the courage to continue that is vital."

HOW TO GET INVOLVED

To join the Global Forum Collaboration Network, email GFNI.Contact-Point@iaea.org

How Is the Pandemic Impacting Utility Customers?

An EPRI survey examines customers' energy use and expectations of their power providers

By Michael Matz

A recent EPRI survey regarding the impact of the coronavirus pandemic on utility customer energy use found that a statistically significant number of customers are using more electricity at home and expecting greater utility assistance during the pandemic. Despite this expectation, fewer than one in 10 residential customers indicated that they are more likely to reach out to utilities for help with their bills. Conducted during the week of April 13, the survey tapped a nationally representative sample of 2,000 respondents.

"These findings suggest that customers want their utilities to be proactive about providing information and assistance to help manage their bills," said Omar Siddiqui, EPRI expert on utility customer behavior and energy use.

Indeed, utilities have been proactive during the pandemic. Many power companies across the United States have suspended electricity disconnects for non-payment in their service territories.

Other key survey findings:

- While 49% of respondents reported increased energy use from electronic devices and 30% reported more lighting and kitchen appliance use, 34% said that their overall household costs were lower as a result of savings in other expenses.
- 40% of respondents said that they expect their utility to provide energy savings advice.
- 25% expect their utility to offer programs and products to help reduce energy use and bills.
- 26% expect their utility to offer alternative rate plans during the pandemic.

"Rather than create a new rate structure that would require approval from state public utility commissions, utilities can remind their customers about the alternative rate plans and programs that they already offer," said Siddiqui. "For example, customers can sign up for existing time-of-use plans that enable them to save money by reducing energy use during expensive, peak demand periods. More participation in time-of-use plans is also in utilities' interest because it helps them reduce their peak demand. This in turn helps utilities avoid or defer expensive infrastructure projects, enabling more affordable service for customers long term. During the pandemic, utilities have an opportunity to offer information and tools to help their customers make decisions that lead to lower bills."

The survey also revealed that the pandemic's economic impacts on households have reduced the likelihood that customers will purchase energy-efficient appliances, smart thermostats, and other energy technologies in 2020.

"During the pandemic, utilities can take a fresh look at the ways they reduce financial barriers to customer adoption of energy technologies," said Siddiqui. "Examples include on-bill financing for residential customers and even arrangements in which the utility installs and owns equipment and leases it to commercial customers."

As the pandemic continues, Siddiqui is closely monitoring its impacts on utility customers. "One trend to watch is how many employees and employers adopt working from home permanently, how that affects energy use, and to what extent load will shift from the commercial to the residential sector," he said. "How long will the financial hardships related to the pandemic affect customer participation in utility energy efficiency programs and adoption of energy-efficient devices, electric vehicles and other forms of electrification, rooftop solar, energy storage, and other energy technologies? When will there be a rebound?"

KEY EPRI TECHNICAL EXPERTS

Omar Siddiqui, Min Long

How Can Video Conferencing Tools Support Safe Nuclear Plant Operations During the Pandemic?

EPRI and industry stakeholders develop guidance for conducting 'source verifications' remotely

By Michael Matz

In nuclear power, in-person oversight is an essential part of maintaining safe, reliable operations. One type of quality assurance activity, known as *source verification*, involves witnessing important manufacturing processes, inspections, or tests. An example of a source verification is when a nuclear plant owner sends technical personnel to a lab to verify that a plant component is calibrated properly.

Source verifications also are used after certain steps during the manufacturing of expensive or complex components such as pressure vessels, pumps, and motors. Technical personnel may go to a manufacturing facility to witness a test or other quality assurance activity that provides confidence that the component has been fabricated properly and will perform effectively. If any mistakes or defects are identified, they can be corrected before manufacturing proceeds or before the item is shipped to the nuclear plant.

"Source verifications are an effective tool for providing assurance that important components will function reliably," said Marc Tannenbaum, an EPRI technical executive who conducts research on procurement, supply chains, and related quality assurance activities. "They're also used regularly in many other industries such as bridge construction, aviation, ship manufacturing, and the military."

Current U.S. Nuclear Regulatory Commission (NRC) regulations require source verifications to be in-person, but the coronavirus pandemic has challenged the ability to comply. "Travel restrictions and safety concerns may make it impossible for a verifier to get on a plane and travel to a lab or supplier to witness component calibrations and tests," said Tannenbaum. "But failure to complete these verifications can delay plant activities such as maintenance."

In March 2020, several nuclear utilities and suppliers contacted Tannenbaum asking if there was any available EPRI guidance on conducting source verifications remotely using video-conferencing and other communications tools. The inquiries prompted Tannenbaum to convene a series of virtual meetings with procurement and quality assurance experts to develop guidance for use of remote verification during the pandemic. It was a collaborative, iterative process, with participation from utilities, suppliers, and other nuclear power industry stakeholders.

In May 2020, EPRI submitted the completed report to the NRC for review. In September 2020, the NRC transmitted to EPRI a safety evaluation report concluding that appropriate implementation of EPRI's guidance is acceptable for meeting regulatory requirements during a pandemic or other state of emergency. EPRI plans to reissue the guidance with a copy of the NRC's evaluation. The NRC recently accepted a request by Energy Northwest (a consortium of public utilities in Washington state) to use the guidance.

SCREENING CRITERIA AND PROCESS

The EPRI guidance includes screening criteria to determine an activity's eligibility for remote verification. One important criterion is whether an activity can be adequately verified remotely. For example, some straightforward calibration and testing activities may be appropriate for remote verification. On the other hand, certain types of inspections may be ineligible because the inspector may need to examine the item in-person to make an adequate assessment.

"If the verifier is relying on someone holding a video camera who is not trained in the type of inspection being performed, something may be lost in translation," said Tannenbaum.

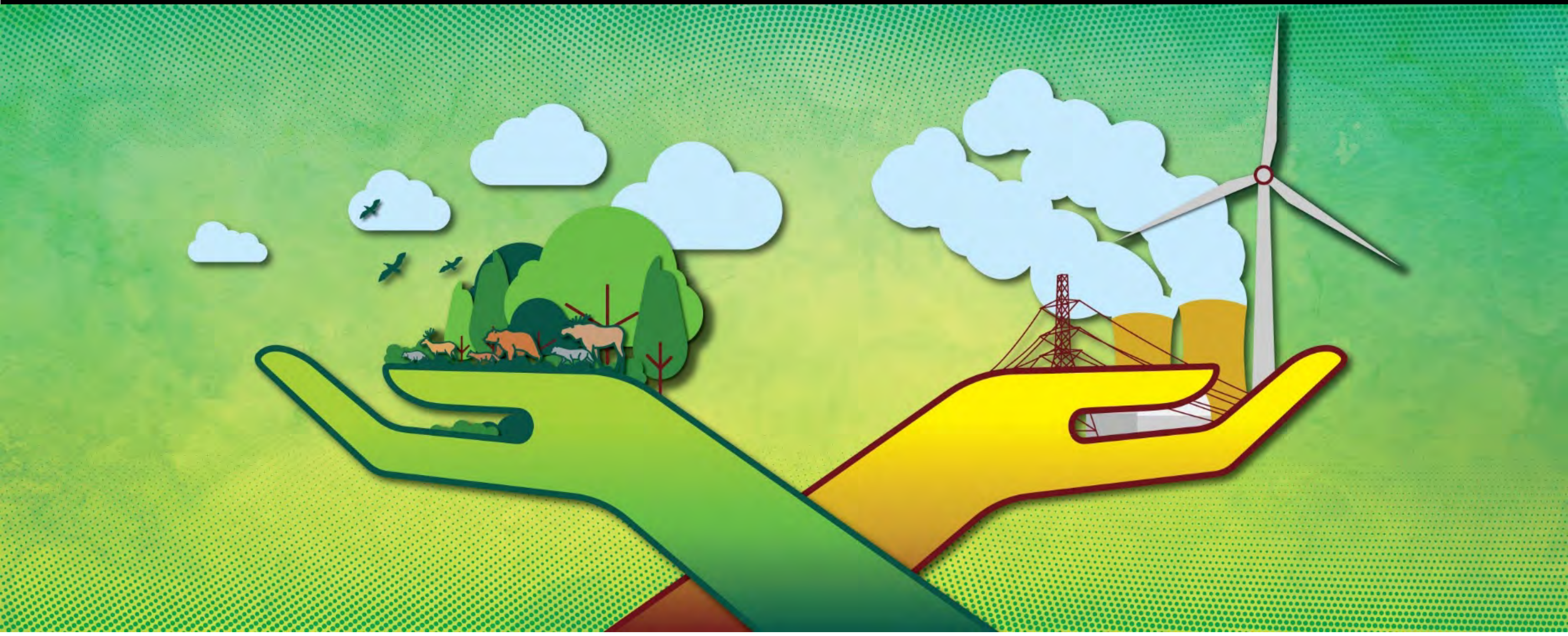
Another key criterion: remote verification needs to be conducted in real-time. "A verifier needs real-time video and audio communication to verify that an activity is completed," said Tannenbaum. "At any point during the verification, the verifier may need to stop the person conducting the activity, request adjustments, or ask for measurements to be double-checked before moving to the next step. This would not be possible with pre-recorded video."

The guidance outlines a detailed process for planning and conducting remote source verifications.

"The most important elements of the process are to define the objectives, have a good plan to accomplish the objectives, and be prepared with contingency plans," said Tannenbaum. "Clearly identify the video cameras and other remote communications tools to be used, the components and activities to be verified, and a 'plan B' to address problems like loss of internet or smartphone signal."

KEY EPRI TECHNICAL EXPERTS

Marc Tannenbaum



How Can Utilities Make the Best Use of Their Dollars for Endangered Species and Conservation?

EPRI and Arizona State University launched the first research project to characterize and estimate the power industry's costs associated with Endangered Species Act compliance

By Lucinda Trew

The wind power industry faces a dilemma as it considers how to address bird and bat fatalities resulting from collision with wind turbines. Particular attention is given to endangered species. To comply with U.S. Fish and Wildlife Service guidelines and Endangered Species Act (ESA) requirements, wind power companies spend millions of dollars each year to monitor bird and bat fatalities at their facilities. Given that collisions of endangered species are rare and that fatality monitoring does not directly support conservation, the large expense raises an important question: Could this money be better spent on efforts that directly conserve or protect endangered birds and bats? It's difficult to answer this question given the lack of understanding of conservation options' costs and benefits.

"Many dollars—and significant time and effort—are being spent to track fatalities of endangered birds and bats," said EPRI Principal Technical Leader Christian Newman. "I wonder whether those resources might be better allocated to purchasing land, protecting habitats, or other conservation efforts aimed at helping those species recover."

The wind industry's dilemma is common in the electric power industry. Power companies allocate significant resources complying with endangered species laws. But little is known about how much money is being spent and on what—and whether these expenses could be targeted in ways that maximize benefits for species. Also unknown are the benefits of voluntary conservation: To what extent does it support imperiled species, avoid ESA species listings, and translate into lower ESA compliance costs long term?

In 2018, EPRI's Endangered and Protected Species Program and Arizona State University (ASU) launched the first research project to characterize and estimate the power industry's costs associated with ESA compliance. They developed a framework of questions to itemize ESA compliance costs during the planning, permitting, construction, operation, and decommissioning of various utility assets, such as substations and power plants. The framework prompts users to determine the specific actions required for ESA compliance and to estimate the associated direct costs (such as labor and materials) and indirect costs (such as insurance and depreciation).

"Understanding the costs of compliance is vital to good decision making at a project, company, and industry level," said Newman. "It can help identify efficiencies; adopt proven, best-in-class standards; and develop more effective conservation practices."

"This is completely uncharted territory," said EPRI Senior Technical Leader Becca Madsen. "Some public agency ESA expenditures are reported annually, but private sector costs have not been. We want to fill that void, and our collaboration with ASU—with its distinguished record of biodiversity research—is helping us do that."

"Understanding the risks and opportunities of conservation is a major frontier in sustainable business development," said Leah Gerber, ASU School of Life Sciences professor, who oversees the EPRI-funded initiative. "We are developing the first comprehensive estimate of costs associated with endangered species regulatory compliance."

Electric utilities are providing feedback on the framework. They also are sharing compliance cost data, and EPRI and ASU are compiling the data to build a first-of-its-kind cost inventory. Newman expects the framework and inventory to inform discussion among participating utilities about opportunities to optimize investments in endangered species and conservation projects. The research may help build a case for voluntary conservation actions by revealing how the costs of such actions compare with the potential costs of future ESA compliance. EPRI is compiling data from electric utilities on voluntary conservation costs.

"We are incorporating the utilities' feedback into the framework and will continue developing and testing it," said Newman. "We also plan to develop guidelines for tracking indirect costs. Our aim with this work is to equip power companies to assess trade-offs in resource management decisions and to consider voluntary conservation alternatives."

While the research has focused initially on the electric power sector, the team envisions application in other industries. "A comprehensive understanding of the costs and benefits of conservation could help many industries allocate resources more effectively and reduce uncertainty regarding future compliance costs," said Newman.

KEY EPRI TECHNICAL EXPERTS

Christian Newman, Becca Madsen

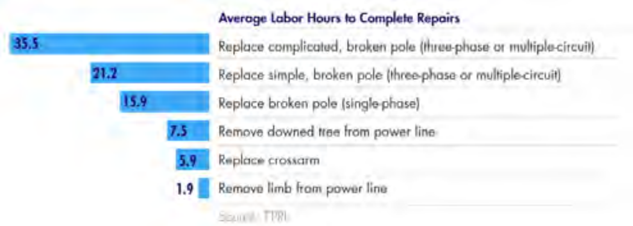
How to Reduce Storm Restoration Times? Design 'Super' Structures

By Michael Matz

Grid operators at Dominion Energy have learned from experience that damaged utility poles are among the most detrimental impacts of severe weather. In 2011, the 1,776 poles damaged by Hurricane Irene took nine days to repair, leaving 1.2 million Dominion customers without power for part or all of that time. Hurricane Isabel in 2003 damaged more than 6,300 poles, interrupting electric service for 1.8 million customers for up to 15 days.

"Dominion Energy has a responsibility to keep businesses operational and support the communities we serve by providing reliable electric service," said Jason Hawkins, manager of electric distribution standards at Dominion Energy. "Based on a review of data from previous major storms, we determined that there was a direct correlation between the number of poles broken during a storm and the total restoration time. We concluded that a new resiliency standard to reduce the number of broken poles would greatly improve overall restoration efforts and allow Dominion Energy to better meet the needs of our customers."

When trees fall on power lines during severe weather, restoration times depend on which components break. Past research by EPRI has demonstrated that it can take 15–35 labor hours to replace a single pole, depending on the complexity of the structure. (A two-person crew working for eight hours is the equivalent of 16 labor hours.) Replacement of a crossarm takes an average of about six labor hours (see chart). In general, damage to pole-top components can be repaired much more quickly than damaged poles.



"If a pole breaks, crews have to transport a pole to the site and complete a great deal of work to set and erect the pole," said EPRI Technical Leader Joe Potvin, who leads research on resilient designs for distribution systems. "If the pole remains intact after a storm, you've eliminated all that site work. To shorten storm restoration times, utilities can design poles so that the pole-top components break before the pole itself."

At its Lenox, Massachusetts site, EPRI built an outdoor facility that enables researchers to simulate tree strikes on various distribution pole designs. For each utility participating in the research, EPRI builds two structures according to the utility's unique design and then interconnects the poles with unenergized power lines. The tree strike is simulated by dropping a large wooden pole on one of the spans (see video). If a pole breaks, the team makes design changes aimed at keeping the pole intact. Modified structures are retested, and additional adjustments are made to improve the structure's resiliency.

"When we simulate tree falls, we observe how the pole system fails and document the order of events—component A breaks before component B which breaks before component C," said Potvin.

Play video

Dominion Energy is one of the 15 utilities from the U.S., Europe, and Canada participating in the research. In 2019, EPRI simulated a tree fall with a structure built according to Dominion's original design, and the pole broke. Based on the test results, Dominion designed a new structure with a wider pole diameter and a crossarm made of fiberglass instead of wood. When the modified design was subjected to a simulated tree fall, the pole did not break. Dominion is using the new design as the basis for its pole resiliency standard and is building new distribution structures according to that standard.

"Our modified design was better in theory, but there was a degree of uncertainty," said Jason Beck, distribution standards technical specialist at Dominion Energy. "Partnering with EPRI gave Dominion Energy the opportunity to test and perfect our new design—and demonstrate that it did not result in broken poles. Using the videos from the EPRI tests, we were able to clearly communicate the results to internal stakeholders and gain their buy-in. In March, the Virginia State Corporation Commission approved the first three years of our ten-year grid hardening program, which allows us to use the new pole standard to upgrade structures in areas with frequent, long-duration outages."

In late 2019, more than 20 utility experts convened at EPRI's Lenox facility to share and discuss the industrywide results. At the end of 2020, EPRI plans to publish a comprehensive report on the research.

KEY EPRI TECHNICAL EXPERTS

Joe Potvin, Drew McGuire

Technology Transfer Awards for Improving Resiliency of Distribution Pole Designs

Several utilities won EPRI Technology Transfer Awards for submitting their distribution pole designs for full-scale testing at EPRI's Lenox, Massachusetts facility and then making design changes based on the results. The awardees were American Electric Power (AEP), BC Hydro, Central Hudson Gas & Electric, Dominion Energy Virginia, DTE Electric Company, Duke Energy, Electricity Supply Board, FirstEnergy, Georgia Power Company, Hydro One Networks, National Grid, and Xcel Energy Services.

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