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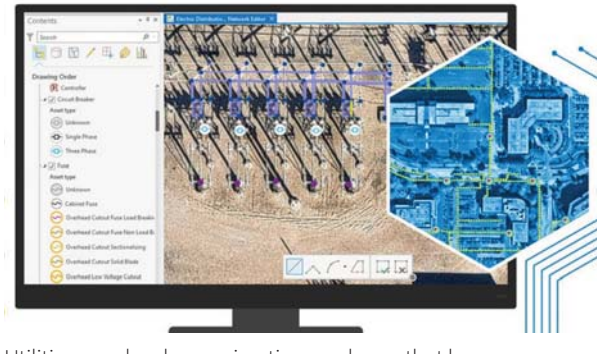

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Power House

I'm writing this month's column during the COVID-19 outbreak. There is a lot of stress and uncertainty in our world right now, and I'm working hard to approach the situation with an attitude of gratitude. I'm personally thankful for the health of my family, a job that I love and the ability to work from home, while also homeschooling my children. Finally, I'm very grateful for the *T&D World* and Endeavor Business Media Energy Group that keep everything running smoothly, even during these challenging times.

T&D World has been providing information to engineers and utility professionals for more than 70 years. We've made a few upgrades that will enable us to do an even better job and I'm excited to share what we've been working on. In addition to *T&D World*, the Endeavor Business Media Energy Group now includes the following brands covering the electric utility industry: Utility Analytics Institute, *Transmission Hub, Utility Products, Distributed Energy*, and Agora Summits. This all enables our team of experts to cover the entire energy industry in a comprehensive manner, like no one else.

Evolving and Engaging

Media channels have evolved, and *T&D World* is now reaching more utility decision makers than ever, so it makes sense that while we remain dedicated to being a trusted source for information, we deliver it in formats that today's audiences expect — at their desk, on their phone, in long-form content in print, or in slide shows.

T&D World is evolving and is engaging with our audience through expanded digital offerings such as bootcamps, webinars, new enewsletters and continuing education courses. Personally, I've been more digitally engaged while at home practicing social distancing. I hope you will also take a few minutes to look around at some of these brands' websites and sign-up for a free enewsletter or print subscription. Finally, I'll sure be happy to see you all again after the travel bans expire, so don't forget that we are offering a series of live in-person events so you can make connections with other deep industry experts, such as at the upcoming *T&D World* Leadership Forum: Wildfire & Risk Mitigation conference in Portland, Oregon.

Award-Winning Team

The *T&D World* editorial team is known for creating high-quality content that attracts and engages leading utilities. Their dedication was recently recognized by being awarded five awards from the American Society of Business Publication Editors (ASBPE). The ASBPE Azbee Awards of Excellence program is one of the most competitive there is for business-to-business, trade, association, and professional publications. The awards recognize outstanding work by content teams producing magazines, newsletters, and digital media.

I'm pleased to share that our T&D World editorial team won the following 2020 Azbee Awards in regional and national categories:

- *Editor's Letter – Global Viewpoint*: Martha Davis, Senior Director of Content
- *Group Profile – Line Legacies*: Amy Fischbach, Field Editor; Martha Davis, Senior Director of Content; Nikki Chandler, Associate Content Director; Susan Lakin, Art Director (Editor's Note: Susan also just celebrated her 28th anniversary working with *T&D World*!)
- *eNewsletter – Lineman Life:* Amy Fischbach, Field Editor
- *eNewsletter – Energizing:* Nikki Chandler, Associate Content Director
- *Photo Gallery – Dawn of the Drones: Ameren Missouri Surveys Storm Damage*: Amy Fischbach, Field Editor

It's exciting to be acknowledged by ASBPE for credibility in covering the electric power industry and experimenting with new content formats. Creating award-winning B2B journalism requires being embedded in industry, understanding critical factors at play, and the ability to synthesize knowledge into useful information. This group of award-winning journalists have a combined 75+ years of energy & B2B media experience between them.

Teamwork

Now this award-winning team is even topping themselves, demonstrating how great they really are through the COVID-19 outbreak. This group embodies the high performance and perseverance described by Churchill: "Success is not final, failure is not fatal: it is the courage to continue that counts." Despite numerous personal adversities — some stranded in Paris during a travel ban, earthquakes in Salt Lake City and homeschooling children — the editorial team is working even harder than ever to capture the strength, resiliency and humanity of our industry during this public health crisis. I am truly blessed to have a team that works hard every single day to build upon the *T&D World* legacy, earn the continued trust of our audience, and who are not satisfied being the very best in our field, but strive to be even better.

Please join me in congratulating this phenomenal group of editors, dedicated to helping utilities solve their biggest challenges.

Also please also join me in welcoming our new editor, Jeff Postelwait (jpostelwait@endeavorb2b.com), and the staff from our new sister publications to the expanded Energy Group. They all make *T&D World* a "powerhouse!" Pun intended. TDW

Senior Director of Content

UPGRADE WITH CONFIDENCE

Upgrading your older substations to meet today's power quality and uptime performance demands is a challenge. To achieve these higher performance levels you frequently need to add CTs. Typically tank-top obstructions and the lack of space present problems.

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It's All About Perspective

By **Gene Wolf**, Technical Writer

Here we are a few months into the new year, and I have been hit with my yearly subscription fees for all the software I use to run my company. It got me thinking about how much my business model has changed over the years due to digital technology trends. I really like the yearly fee for my software with updates throughout the year. Of course that keeps me jumping to stay on top of the changes and additions to my software.

Digital camera equipment.

It was the last invoice that came from my photo-editing software supplier that really got me thinking about how this technology has advanced. There was also an announcement about an upcoming release that would include artificial intelligence (AI) enhanced photo tools. Wow, AI-infused photo-editing tools got my attention! I haven't talked much about the photography I do, but in addition to writing a lot of technical articles and reviewing new technologies for *T&D World*, I do some photographic work too.

One of my earliest photo assignments was to accompany my friend Rick Bush to tour the storm damage caused by Hurricane Ike in the Houston/Galveston area. I packed up all the paraphernalia a hard-working digital photographer needed for field work, which was extensive. Prior to digital technology, my packing was pretty simple — my trusty camera, some filters, a couple of lens, and a flash, but digital photography changed all that.

It Wasn't Easy

Now I needed a laptop chuck-full of photo-editing software along with extra camera batteries, spare camera memory cards, and various chargers plus extension cords. Not to mention I needed a portable hard drive to back up the photo files. All of this also required a carryon bag to prevent damage and loss, but it gave me something I never had before. I had all the tools I needed to process photos in the field, which was a quantum leap forward over my darkroom days.

With this technology, we had an important advantage for bringing our readers the restoration story as it was happening. During the daylight hours we visited the people and the places where the rebuilding of the grid was taking place. We took a lot of notes and photographs. In the evening while I processed the photos in my laptop, Rick put our notes in order. Then we wrote the stories of the day, added the photos, and uploaded the day's package to our support team at the magazine.

That laptop with its photo-editing software was indispensable for me. After all, one good graphic sets off the story for our readers the way nothing else can. By today's standards that photo-editing software was pretty primitive. It was not very user friendly and required a lot of finesse on the part of the user.

Despite all the additional hardware/knowledge the technology required, it quickly won acceptance within the amateur and professional photography ranks. Interestingly, the digital camera was invented by a film manufacturer, but the manufacturer didn't pursue the technology. Others did, however, and the rest is history. When was the last time you have seen a roll of film for sale at the local drug store?

Awareness Counts

I'm guessing that is why so many emerging technologies are called disruptive when they may actually be transformational. That's why it is so important to keep an open mind. Whether the technology is disruptive or transformational depends on the perspective of the viewer.

To the customer, rooftop solar-plus-storage may be transformational because it gives them a way to lower their electric bill while improving the environment. To the utility, it may be disruptive because it is reducing load while the customer expects the utility to provide power when the sun isn't shining, and their storage is empty.

A more positive approach is occurring where utilities and customers are taking a partnering attitude. A good example is in Australia. South Australia, the state utility, and Tesla are providing solar-plus-storage for homeowners. The homeowners take advantage of the solar-plus-storage and the utility gets grid support when needed.

Closer to home, Green Mountain Power, Liberty Utilities, and National Grid have pilot projects offering customers energy storage equipment for a demand response program where all parties benefit. I read one report that said California hit one million rooftop solar installations in 2019 and it's not just California. Dropping prices are encouraging solar-plus-storage to spread over the country. Being transformational is much better than disruptional! TDW

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ABB and Verdigris Announce Partnership to Manage Energy Through New Machine Learning

ABB and Verdigris Technologies have formed a partnership to bring Verdigris' machine-learning applications to ABB's global line of connected low-voltage switching fabric products. The combination will predict unplanned surges in power consumption for commercial and industrial buildings. ABB is launching a new digital energy app-store and Verdigris' artificial intelligence (AI) technology is their first app.

Through both internal and field studies with ABB, Verdigris demonstrated near-range energy forecasts with greater than 90% accuracy, useful in demand management applications, and outperformed common open-source forecasting alternatives.

Andrea Temporiti, digital leader for ABB's Electrification business, said: "With the new Energy Forecasting and Smart Alerts apps, AI drills down into the facility's power data to pinpoint actionable opportunities for productivity improvements and energy cost savings."

According to the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy, connected sensor networks and advanced monitoring and analytics combined with adaptive and autonomous controls have a technical potential to save a wasted 3.31 quads of energy or US$43 billion annually.

Jonathan Chu, Verdigris CTO said: "DOE Studies show with accurate sensing and predictive analytics we can reduce building energy consumption by up to 30%. With AI we have the building blocks to go further in developing adaptive and autonomous buildings, and eventually optimize networked fleets of generators, energy storage systems, EV infrastructure and smart buildings." Further collaboration between ABB and Verdigris to advance AI capability on electrical infrastructure are planned.

AutoGrid and Schneider Electric Announce Integrated ADMS and DERMs Solution

AutoGrid has announced a partnership with global energy management and automation specialist Schneider Electric. The partnership will help energy providers integrate customer-owned or -operated flexible distributed energy resources (DERs) into their distribution management operations.

The partners will integrate Schneider Electric's EcoStruxure Advanced Distribution Management System (ADMS) with AutoGrid's Flex, the energy industry's first fully-integrated flexibility management application, which uses the open standard IEEE 2030.5 to exchange data and control signals.

"As distributed energy resources proliferate, electric utilities want a way to balance supply and demand across a complex, dynamic and multi-directional network," said Amit Narayan, chief executive officer of AutoGrid. "Combining our solution with Schneider's capabilities allows energy providers to harness data to balance a distributed grid with flexible capacity from all grid-connected DERs."

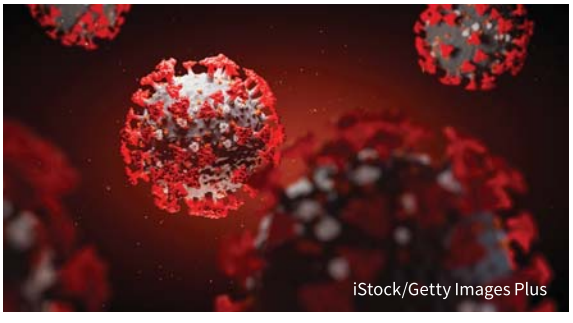
The joint effort offers new capabilities that will enable a comprehensive approach to modeling, forecasting, optimizing and orchestrating flexibility from all behind-the-meter (BTM) DERs connected to the electricity grid. This brings unprecedented real-time visibility and control across the full spectrum of BTM and front-of-the meter utility-scale assets such as energy storage, solar PV, wind, thermostats, water heaters, electric vehicle chargers, and commercial and industrial demand response for transmission and distribution network operators.

Much of the activity in the new energy landscape has shifted to the area behind the meter and its grid-edge assets. With AutoGrid Flex, regulated utilities can aggregate, optimize and manage behind-the-meter assets directly from the control center for applications such as demand management, renewable balancing and peak load reduction.

The ability to utilize DER assets for grid management will enable utility customers to maximize their return on investment by getting compensated for providing grid services or through participation in wholesale markets. Utilities benefit by growing capacity without the expense of updating grid infrastructure and improving overall power quality and system reliability. They can pass these savings to energy consumers, creating a virtuous cycle for adoption of new energy technologies. TDW

COVID-19 Hits U.S.; IEEE PES Postpones 2020 T&D Conference and Expo to October

Even as the World Health Organization declared COVID-19 a pandemic on March 11, the virus had spread to 114 countries. Internationally, several nations were already restricting travel and social gatherings. As the virus multiplied in the United States, most utilities shifted into crisis mode, banning travel for employees and accouncing that they were suspending shutoffs for the time being.


iStock/Getty Images Plus

States and localities encouraged and even mandated the cancellations of events if they hadn't already been postponed or canceled. The IEEE Power & Energy Society is postponing its T&D conference and exposition to Oct. 12-15, 2020, with the exhibits open from Oct. 13-15, 2020, at the McCormick Place South in Chicago, Illinois, U.S. TDW

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The Grid: Smart and Autonomous

Self-managing technologies are bridging the gap between the traditional centralized grid and today's growing distributed grid.

By **Gene Wolf**, Technical Writer

It is hard to imagine the electric power grid operating autonomously. Even the name autonomous grid sounds like a science fiction scenario, or does it? The idea of the autonomous grid has been around for a really long time, but like so many advanced theories, the necessary technology needs development. The noteworthy thing about digital technology is it keeps advancing, and a few years ago a lot of the necessary building blocks began to take shape.

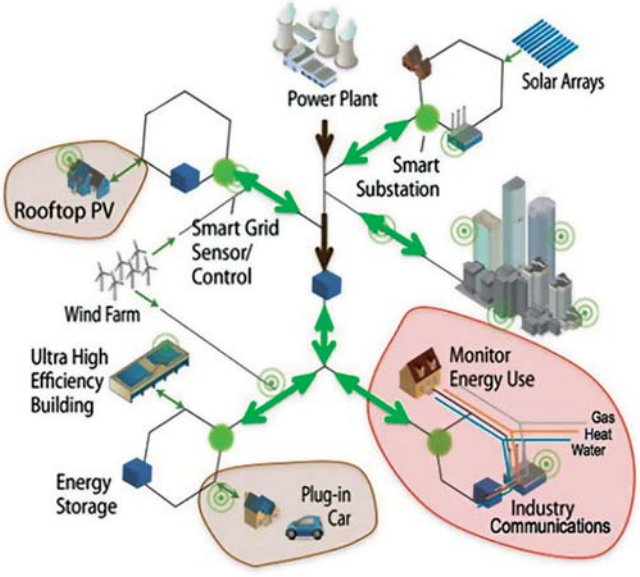
Transformational technologies like distributed energy resources (DER) and renewables will definitely be able to use the abilities of an autonomous technology as their penetration increases. Let's look at what is meant by autonomous. One of the best definitions comes from the Department of Energy's (DOE) National Renewable Energy Laboratory (NREL). NREL defines autonomous as, "Capable of making decisions and operations without humans in the loop."

It is a self-managing technology, with the ability to adjust to the real-time dynamics of the grid. The technology is being applied to transform today's grid into an autonomous energy grid (AEG). An AEG is a fast acting, self-driving power system that can make decisions on its own. As a result, it is also self-organizing, self-optimizing, and utilizes narrow artificial intelligence (AI) for control.

Fact from Fiction

The standard mental imagine most of us have for autonomous probably isn't a positive one, but it should be. It is a good bet that most of us use an autonomous vehicle nearly every workday. If you use an elevator, you do. That is correct, an elevator is an autonomous vehicle, but it's called self-service not autonomous. Self-service elevators were developed around 1900, but people weren't comfortable with the technology and they refused to use them. The experts, of the day, were totally against the technology predicting all manner of calamities if the technology was allowed — sound familiar?

That all changed in 1945 when the elevator operators went on strike in New York City. It almost shut down the city and impacted business. Suddenly self-service elevators weren't so bad, and the technology was adopted. A few years later automatic self-service elevators were being installed in buildings around the world. Self-service (autonomous) elevators became common place and the collective consciousness moved on to other topics. Today, no one gives a second thought about using them.



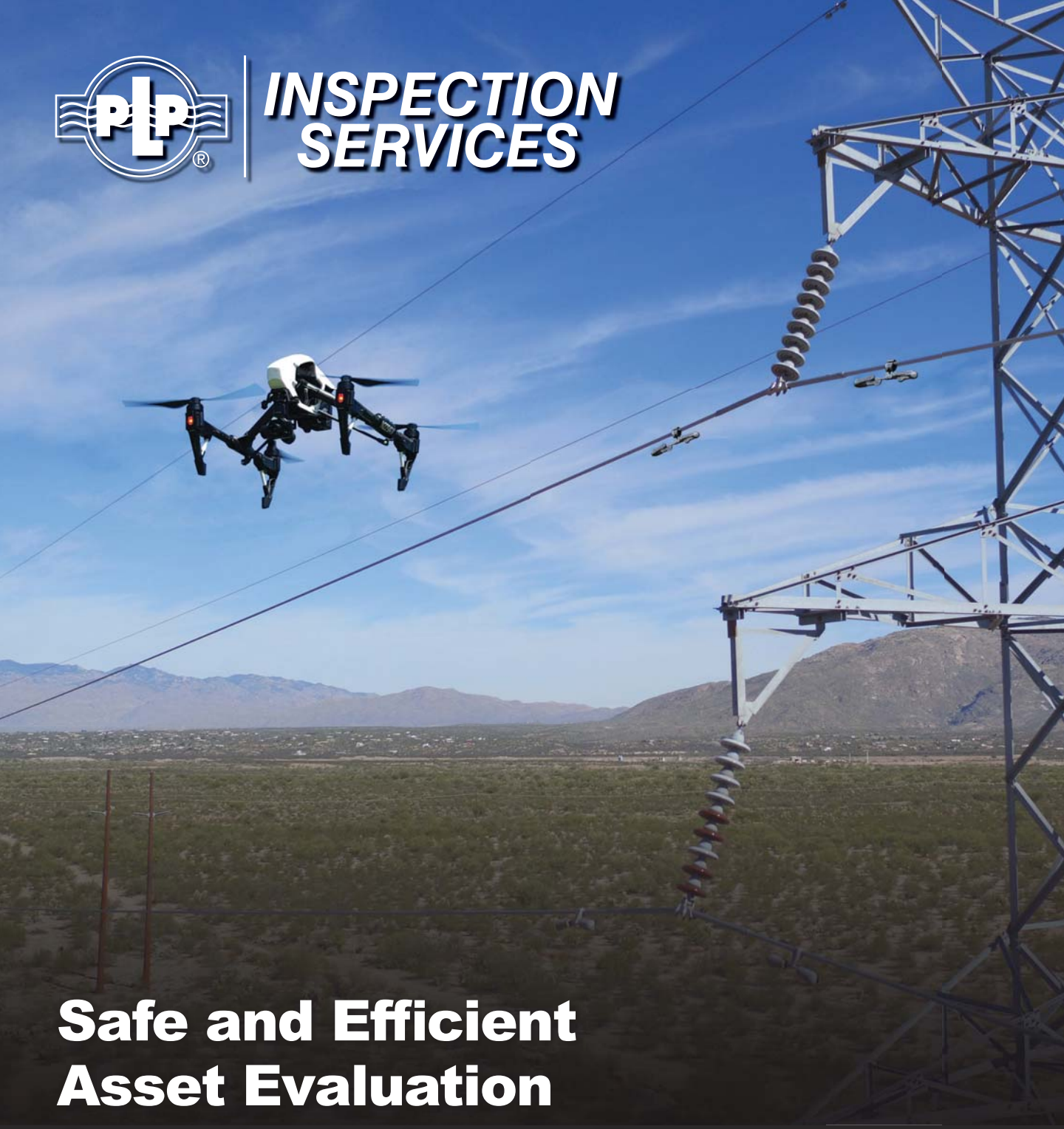
The AEG. Courtesy of NREL.

Interconnected Applications

For AEGs to be feasible there are some advanced digital technology building blocks that have to work together to make AEG technology work. AEGs are not going to happen without taking advantage of both the physical and virtual world technologies because its foundation is set in both. Fortunately, there is an advanced digital technology that is focused exactly on that aspect — digital twins.

Digital twin technology links the physical world with the virtual world in a unique manner. Keeping it simple, digital twinning takes advantage of smart grid's interconnectivity of intelligent sensors transducers and advanced communication systems. The physical devices produce big data in astounding amounts. At this point, the virtual world takes over with cloud-based computing technology and sophisticated software including built-in narrow AI for big-data analytics.

It's what IBM called "predictive insights," which enables relationships to happen across technological boundaries. Digital twin technology provides the user with understanding through modelling and monitoring, but that isn't all. It also



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predicts what will happen, and optimize what is taking place. In other words, digital twinning supplies tangible tools from this virtual reality for the physical grid.

By wrapping all these interrelated technologies together, companies such as ABB, Bentley, GE, IBM, Siemens, and others have opened the door for digital twin technology to be applied on transmission grid and distribution networks. The development of these applications are critical for the development of the AEG, but there is still a long way to go before we see the widespread application of AEG technology on the grid.

Another digital building block technology needed in the development of AEGs is the virtual power plant (VPP). It has been put in the spotlight by the behind-the-market (BTM) distributed energy resources (DER) market. VPP technology allows thousands of BTM-DER devices to operate similarly to a larger grid-scale brick and mortar power plant. Like the digital twin application, the VPP component is one more element needed the development of AEGs.

BTM-DER Trifecta

Let's look at BTM-DER technology. It's one of the fastest growing technologies on the grid because it has represents a trifecta of customer needs. DER gives the customer a choice of energy products, it is super user friendly, and its prices are dropping constantly. With all of that going for it, it is no wonder that industrial, commercial, and residential customers have embraced the technology as they have.

Because of the growing numbers of BTM-DER devices (rooftop solar, fuel cells, batteries, electric vehicles, etc.) the customer base has morphed into prosumers and prosumagers. These two groups have recognized that the technology offers them the ability to monetize their BTM-DER investment. It gives them the opportunity to enter the distribution market, which is starting to attract the attention of some of the grid's stakeholders.

The 2019 Black & Veatch (B&V) "Strategic Directions Report" asked the participating utilities "if they anticipate the introduction of distribution markets for DER owners?" The report said 36.8% said yes and 16.7% said no. Remarkably 46.5% responded that they didn't know (the full report is available on the B&V website). Navigant Research published a report in 2019 saying, the global annual revenue for DER capacity is expected to grow from $172.5 billion in 2019 to $649.6 billion in 2028. With figures like these, B&V's "didn't" category should be substantially reduced in size.

Depending on who is quoting the figures, the numbers of installed DER devices is growing tremendously. The figures run from millions to hundreds of millions, but the important take-away is the amount of individual BTM-DER devices that will be unmanageable with traditional methods in the not-too-distant future, which is why VPP technology is so important to the grid.

AEG Activity

That is the reason it is so important to see action from DOE in the form of funding for projects related to this type of activity. AEG technology needs a great deal of computer power. It also needs standards and standardization. In 2019, DOE announced it was funding the Grid Modernization Lab Call Projects with US$80 million to be spent over three years. It is a partnership between DOE and the National Laboratories. Among the projects, NREL is working to develop a method for aggregating a variety of market DERs. PNNL (Pacific Northwest National Laboratory) has a project focused on enabling networked microgrids and component DERs to operate in an intelligent manner using collaborative autonomy concepts.

Another DOE project is a partnership between PNNL, NREL, and Siemens to develop an energy management system that can coordinate distributed microgrids to work together. The system will autonomously restore power during blackouts using diverse technologies and smart invertors.

NREL has published several papers and press releases discussing AEG research. They see the AEG as a bottom-up configuration starting with campuses and communities, which makes a lot of sense when dealing with a machine as complex and complicated as the electrical grid.

In keeping with that philosophy, there have been some interesting technical development projects. Hawaiian Electric Companies (HECO) has a grid modernization plan and a mandated goal of 100% renewable generation by 2045 (See "Straight Talk" on page...). By some estimates they have about 250,000 inverters on their system from rooftop solar systems, and the number keeps growing. An AEG would be advantageous in this area, but HECO and NREL are starting with autonomous advanced inverter functionality, which manages the individual devices.

Another project is the Holy Cross Energy (HCE) and NREL DER management partnership in Basalt, Colorado, U.S. The partnership, which set up an autonomous energy grid to share electricity among solar panels, batteries, heaters, and vehicles, connected several homes in a neighborhood in the Basalt Vista Affordable Housing Community.

NREL said, "The equipped homes can exchange energy and services with neighbors, matching generation and demand intelligently and on the fly while respecting the reliability limitation of the local grid." The partnership stated, "The approach has been described as a virtual power plant and is the outcome of field-advancing algorithms that only existed in imaginations several years ago." Their motto is "think big, start small."

The building blocks of an AEG are available, but they haven't been turned into a network of technologies required to work together efficiently yet. Narrow AI has been infused into every digital technology applied to the grid. Digital twin systems have been deployed as have VPP made up of thousands of BTM-DER systems. Self-directed asset management systems are making decisions at utilities around the world. It's going to be very interesting watching all these diverse applications being integrated into an AEG system capable of self-operation. TDW

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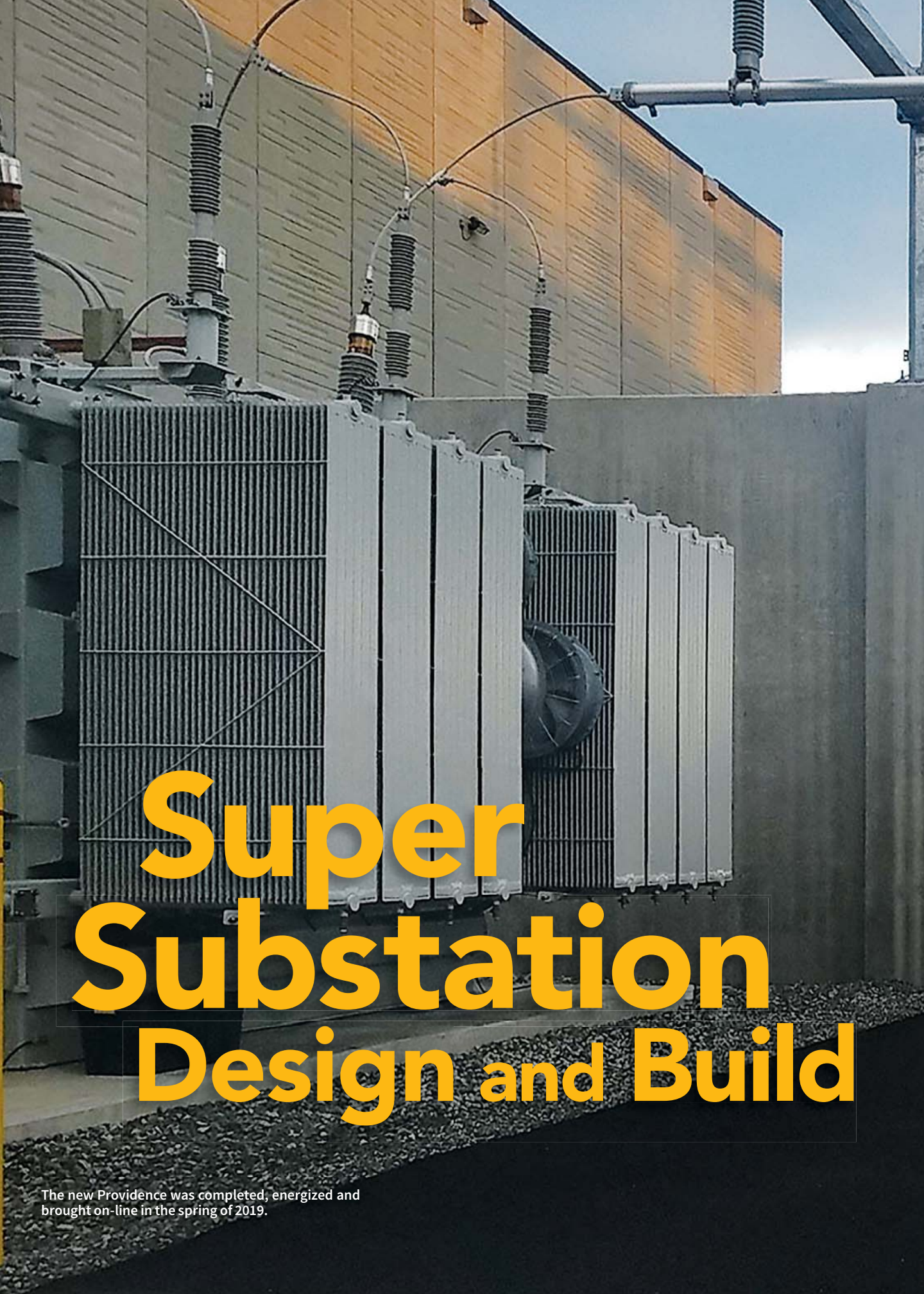


Super Substation Design and Build

The new Providence was completed, energized and brought on-line in the spring of 2019.

National Grid tackles the challenges of replacing a 100-year-old substation in the heart of Providence.

By **Nelson Antunes**, **Kalpana Dulipsingh**, and **Michael Morin**, National Grid

In 1919, the South Street substation opened as a state-of-the-art piece of critical infrastructure to help keep the lights on in the largest city in the U.S.'s smallest state, Providence, Rhode Island. Three 115-kV transmission lines delivered electricity to the substation, which then stepped down the voltage and sent it out to the state's capital to nearby smaller substations. The typical substation built at that time had six circuits that sent out power; the South Street substation had 48 circuits.

For 100 years, such institutions as Brown University, Women & Infants Hospital, Rhode Island Hospital, Roger Williams Medical Center, the Veterans Administration Hospital and surrounding areas relied on the substation to provide energy that powered the state's largest, most important economy. Together with the Franklin Square substation, the South Street substation provided electrical service to 150 MW of load in downtown Providence, including the downtown network, 10 distribution substations and hospitals. Owned and operated by National Grid plc, the substation performed admirably. For decades, it never experienced an outage, and it served as a vital cog in the city's economic engine.

Fast forward to 2016, and the city of Providence's aggres-

The project consisted of the construction and installation of a two-story control building with 48 breakers and 27 feeder positions, which were made up of 49 sets of cables.

sive plans for growth and economic development could no longer be sustained by the 100-year-old electrical substation. National Grid was faced with the challenge of ensuring safe, reliable energy coverage for the dense, busy urban city while effectively replacing the entire South Street substation. A five-year study completed by National Grid in 2014 identified a new substation as being critical for the continued safe and reliable delivery of electricity to the utility's customers and much of the city.

Planning for Growth

The Davol Square section of the Providence Riverfront, located in the vicinity of Eddy Street, is undergoing a major redevelopment, taking advantage of parcels that became available after the relocation of Interstate 95. A partnership among the city of Providence, local universities and developers is proposing to build laboratories, classrooms, parking and dormitories on these parcels.

Another initiative is the Interstate 195 project, the Providence Innovation & Design District, launched in 2013 to redevelop land in the heart of the city to encourage growth, create jobs and enhance the city's economic opportunity. When completed, the district will have a Science & Innovation Center, high-tech offices, residential condominiums and apartments, shopping, restaurants, public parks and more.

The legacy South Street substation was a 115/11.5-kV station consisting of the following:

- Outdoor yard housing three 115/11.5-kV power transformers (two rated 56 MVA and one rated 50 MVA), four 11.5/23-kV transformers (two rated 10 MVA and two rated 7.5 MVA) and an interconnecting bus
- 11.5-kV, three-section, segregated phase switchgear originally consisting of 76 oil-filled circuit breakers supplying 35 circuits and located inside a three-story brick building.

At 100 years old, equipment at the substation was no longer supported by the manufacturer. Spare parts had to be manufactured by a local machine shop using parts from retired equipment as a guideline. Modern 11.5-kV switchgear could not be retrofitted into the existing building as the current practice is to use non-segregated phase equipment. Additionally, the building that housed the switchgear needed structural repairs. As a result, National Grid determined a new substation was needed.

In 2016, the utility broke ground on the new substation, including a completely new building to house the infrastructure along with outdoor switching equipment. The new facility was located behind the South Street Landing parking garage and adjacent to the Providence River.

Managing Challenges

There were extensive challenges in designing and building the project. National Grid had to balance safety, power quality, reliability, operational flexibility, future expansion, aesthetics and cost. As a whole, the project consisted of the construction and installation of a two-story control building with 48 breakers and 27 feeder positions, which were made up of 49 sets of cables.

The utility was building the new substation while immediate abutters also were constructing projects, a parking garage and the remodel of a historical building. Construction of the control building was challenging because of the number of contractors at the site an any given times. At the peak of construction, more than 100 people were working on-site at any time.

Working in such a confined area in the bustling downtown Providence area became extremely challenging because of the construction traffic from the three concurrent projects. The limited construction space also made it difficult to handle and store all the contaminated dirt that was excavated while installing numerous T&D duct banks.

Aside from coordination challenges with other construction, the work itself was highly complex. Existing underground facilities, such as water, sewer, communications, electric duct banks and other abandoned foundations, became difficult to overcome when designing and constructing the T&D duct banks. To solve the issue, National Grid raised the site in certain areas to install the distribution duct bank. For the transmission duct bank, workers had to install the bank approximately 15 ft to 20 ft (4.6 m to 6.1 m) deep and use pipe jacking means to install a centrifugally cast fiberglass reinforced polymer mortar (CCFRPM) pipe, and then install the needed conduit.

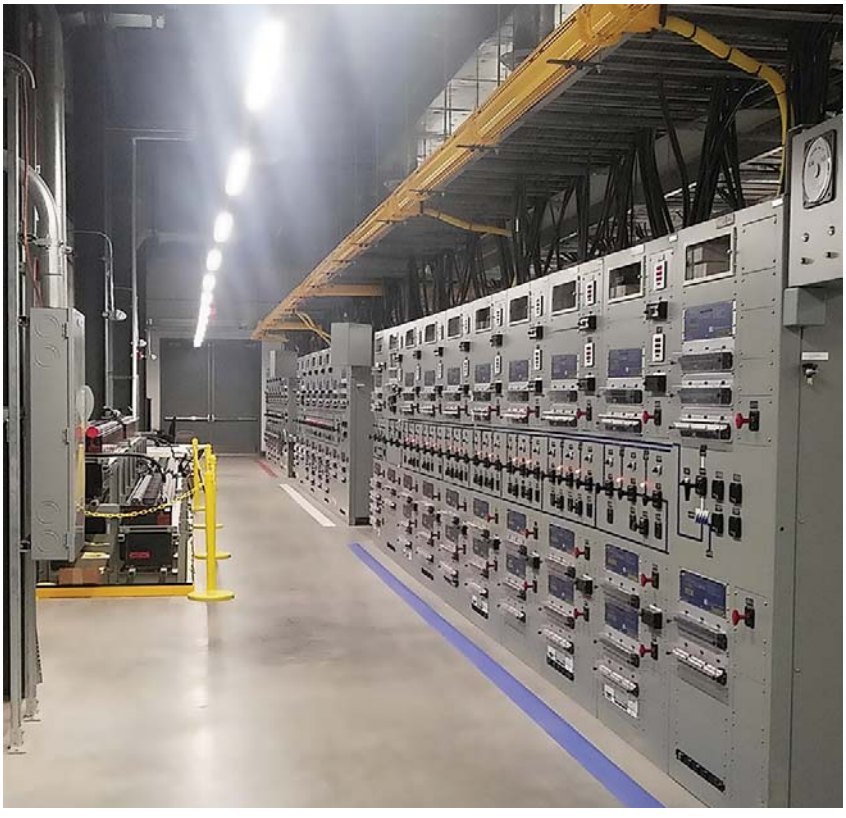
Routing of the distribution cables through the basement of the control building also was challenging. Cable trays were

installed as raceways to route the cables to the designated breakers. National Grid's new transmission underground cables had to be installed through the property of one of the other projects.

Design Focus

When designing the substation, National Grid sought to install state-of-the-art technology. One example is the 63-kA rated arc-resistant switchgear manufactured by Siemens to replace the dated breakers and protection scheme in the old substation. In addition, fiber-optic cables were installed as a communication means between the new South Street substation and connecting substations.

The project also was designed to uphold the highest safety standards for National Grid employees, residents in the local area and customers. Safety design features of the substation include enhancements to address existing indoor operating concerns, arc-flash-resistant switchgear, fault current mitigation and a Kirk Key interlock system for switching operation. The metal enclosed disconnect switches were designed



The building was designed to safely support the major equipment during normal operations and withstand system faults. The main switchboard control room is pictured here.

Because of the limited space available to build a new substation while keeping the existing substation operational, TRC Companies Inc. was contracted to design a building to house some of the major equipment, including the 63-kA switchgear, indoor reactors and switches.

with special barriers to isolate workers from energized parts.

Because of the limited space available to build a new substation, while keeping the existing substation operational, TRC Companies Inc. was contracted to design a two-story control building to house some of the major equipment, including the 63-kA switchgear, indoor reactors and switches. The building was designed to safely support the major equipment during normal operations and withstand system faults. This included structural reinforcements in the walls, roof and floors as well as the equipment and cable constraints. Although the building was robust and seismic, the concrete floor deflected enough during the installation of the switchgear that it became difficult to assemble the gear.

Not only does the two-story control building hide a portion of the substation equipment, it also was designed to blend in with the city's overall vibe. Kite Architects designed the exterior of the control building that houses the substation equipment. Stamped-concrete panels include detailing of interference waves in homage to the physics of electricity. Vents, louvers and observation windows also were artfully placed to showcase the critical infrastructure contained within the building.

The basement of the control building houses more than 25 11.5-kV distribution circuits, which required a complicated layout. TRC adopted the Bentley substation tool to create 3-D models and walk-throughs to present, discuss and fine-tune South Street's complicated design.

"Bentley substation software was a critical design tool enabling us to engineer, coordinate, and share data models and 3D dynamic visualizations with members of the multi-disciplined design team and most importantly, National Grid, in the design and construction of this facility," TRC Principal Engineer William J. Bell, PE said. This better enabled consulting

The outdoor yard housed three 115/11.5-kV power transformers and four 11.5/23-kV transformers.

architects and engineers to develop an integrated design that worked throughout the overall station with minimal changes before the shovels ever hit the ground.

Super Substation

The project was initially estimated to cost US$95 million to build. By finding some efficiencies, including cost savings in equipment, limiting the scope of the project and limiting excavation of the site, the final cost of the station was $10 million less, at $85 million. This new super substation is enabling National Grid to contribute to the revitalization of downtown Providence and transform the land near I-195.

"The South Street Substation allows us to supply existing and new electrical loads as a result of all of the new construction that is taking place in the Providence downtown area" Antunes said.

The new substation also is significantly easier to operate and maintain. "Going from a one- and two-bus system to a breaker-and-half allows us to cut down on maintenance hours," said Mike Morin, lead supervisor at National Grid for substation maintenance in Rhode Island. "In the old South Street substation, it would take six switch persons nine hours to transfer the bus to do maintenance on one breaker. All disconnect switches were hand operated and checked open on three floors.

"Now breakers are SCADA operated and are remotely racked out, cutting switching time for maintenance from hours down to minutes and allowing us a higher standard of safety

National Grid installed 63-kA rated arc-resistant switchgear manufactured by Siemens to replace the dated breakers and protection scheme in the old substation.

when performing the switching task," Morin continued. "Having modern equipment streamlines our maintenance, since having available replacement parts on hand and being able to swap breakers from one cube to the next enhances our reliability."

The biggest challenge for operation personnel was the complexity of phasing the old station and new station, as a result of the indoor radius bus turns and three sections as well as the old station being 300 ft (91 m) away. "This is a great project and one of the biggest substations on the East Coast," Antunes said.

The new substation was finally completed, energized and brought on-line in the spring of 2019. Demolition of the old substation was the last task to be done. It completed in the fall, with the last brick of the old station being hauled away in November 2019.

From the complexity of the substation and the congested work zone to the challenges of demolishing the old substation and working with the many partners involved with the development of the downtown area, the vast scope of work made the South Street substation a challenging yet rewarding project. With this new super substation in place, Providence will be powered well into the future. TDW

Nelson Antunes (nelson.antunes@nationalgrid.com) is a lead project manager at National Grid who is responsible for managing distribution, transmission and substation projects throughout their full lifecycle. Nelson joined National Grid in 2003 as a distribution engineer responsible for designing various complex distribution services. He is an electrical engineer with a Masters in power systems management with a project management certification from the Project Management Institute and is a registered Certified Utility Safety Professional (CUSP).

Kalpana Dulipsingh (kalpana.dulipsingh@nationalgrid.com) is a manager with the Substation Engineering and Design Group at National Grid, having joined in 2009 after working as an electrical engineer for more than 15 years in other organizations. She has a masters in electrical power engineering from Rensselaer Polytechnic Institute and is a certified professional engineer and project manager.

Michael Morin (michael.morin@nationalgrid.com) is a lead operations supervisor of Rhode Island Substations at National Grid, responsible for the safe, efficient and reliable operation of more than 111 transmission and distribution stations in Rhode Island. Morin leads a team of 49 substation supervisors and maintenance personnel. He has been a member of the National Grid team for 33 years. Morin received his undergraduate degree from Holy Name University.

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EVERY CONNECTION COUNTS

Pecan Street's research network includes more than 1000 volunteer participants whose home energy use (and, for solar residents, generation) is measured and analyzed in real-time.

The Energy Switch: A Residential Microgrid

The Energy Switch turns an unreliable generation resource that requires close attention into a more beneficial load on the system.

By **Scott Hinson**, Pecan Street Inc.

As part of DOE-FOA-0001225, a Department of Energy-funded program in conjunction with Concurrent Design, Pecan Street developed a residential microgrid called The Energy Switch. The program was a fast-paced, one-year development that included a two-month demonstration and ended with NREL doing a third-party validation of performance.

Several years ago, power quality monitoring equipment was installed in several homes with solar PV in Pecan Street's Austin testbed. The results were not necessarily surprising, but they did point to issues that the previous generation of legacy inverters or the current generation of Rule 21-compliant smart inverters did not address.

One of those issues was the resultant power factor at the service entrance of a modern residential structure. The solar often replaces the real power load of the structure, leaving the utility to support the reactive power portion of the load.

In many of the engineering texts for power distribution, the classical assumption is that a residential structure is a significantly high-quality load, typically a power factor of 0.95. Unfortunately, that is no longer the case; structures without solar are commonly measured at total power factors of below 0.8, sometimes falling below 0.7. Making matters more complicated for system planners, total power factor is composed of two components: distortion and displacement.

Historically, when homes fall below a power factor of 0.95-0.97, the power factor has been mostly caused by current displacement and has been lagging, because of the motors for HVAC systems and refrigerators. Modern home loads do not show this behavior; the switch-mode power supplies for CFL/LED lighting, variable speed drives, set-top boxes, phone chargers and computers rarely seem to be power factor-corrected well to keep costs low. Individual set-top boxes, washing machines and high-efficiency lighting have been measured at a power factor under 0.6. Making it more complicated is that the fundamental displacement current in these devices is often leading. Houses have been measured changing from leading to lagging loads 70 times a day. Add to that the more well-known issues of matching the generation to the load profile, voltage control, congestion management and demand response needs, and Pecan Street thought that there was an opportunity for a very smart energy storage system.

The Energy Switch is a complex system that includes:

- 10-kWh energy storage.
- 9.5-kW peak power.
- 24 circuits of load control/monitoring.

• API addressable.
• Capable of supporting ac or dc solar connection.
• Maintains operation of ac-coupled solar during a grid outage.
• Accepts grid, generator and ac solar input energy.
• Can discharge battery to provide real/ reactive power grid support.
• Can set limits of both generation and load demand power.
• Can support black start through multiple behaviors, including immediate reconnect and generation, or delayed reconnection maintaining residential power throughout the blackout.

The end-user has access to five operating modes:

1. *Maximize self consumption* – keeps as much local generation as possible, minimizing reverse flows to the grid.

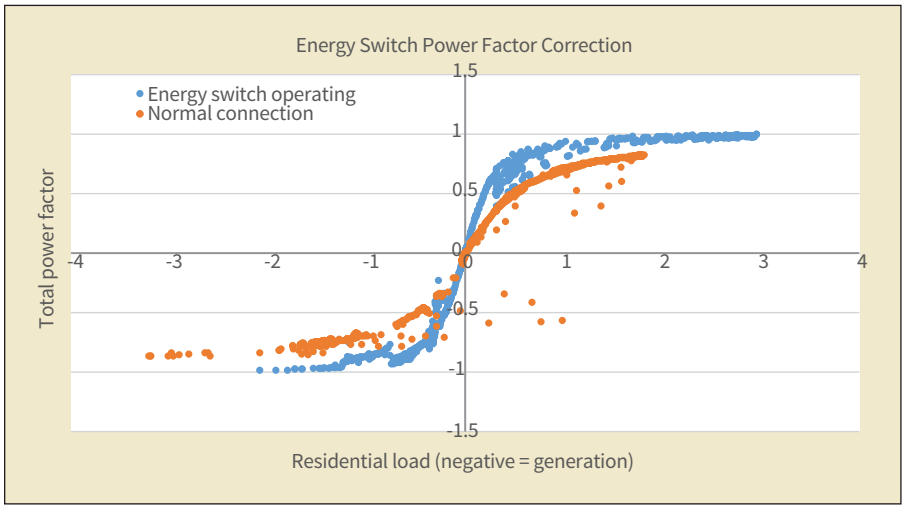
2. *Maximize grid suppor*t – the system monitors grid voltage and provide power or load as necessary using a voltage set point as the trigger for generation/load.

3. *Grid outage without secondary generation* – the system shuts off all but the critical load circuits to maximize battery life during an outage. Excess solar production is routed to the batteries or curtailed if necessary.

4. *Grid outage with secondary generation* – the system signals a generator to start and reconnect a portion or all of the circuits disconnected in Mode 3.

5. *Maintenance* – the system reconnects to the grid, legacy ac solar generation is reconnected to the grid and the internal-

The Energy Switch is a complex system that includes energy storage and load control and monitoring.



Energy Switch load leveling and power factor correction performance.

systems of the energy switch are safe for troubleshooting and maintenance.

Leaving the end-user with so many operating mode choices was more of an engineering decision and probably a mistake. The end users really should experience a fully automated system that moves between the modes as required by external conditions or API requests.

A dc-dc coupled architecture was chosen. It provided the full-time power factor correction and "flicker"-free islanding in the event of a DR event or grid outage. Essentially the residential structure runs of an inverter full time, connected to the dc bus. The dc bus itself has the flexibility of accepting battery inputs or battery and solar inputs with appropriate charge control.

The ac system bus has a series of contactors and extremely high-speed monitoring. A legacy grid-tied solar system can be connected either directly to the output of the Energy Switch or the grid. This gives the homeowner the ability to maximize production, self- consumption or battery charging energy source.

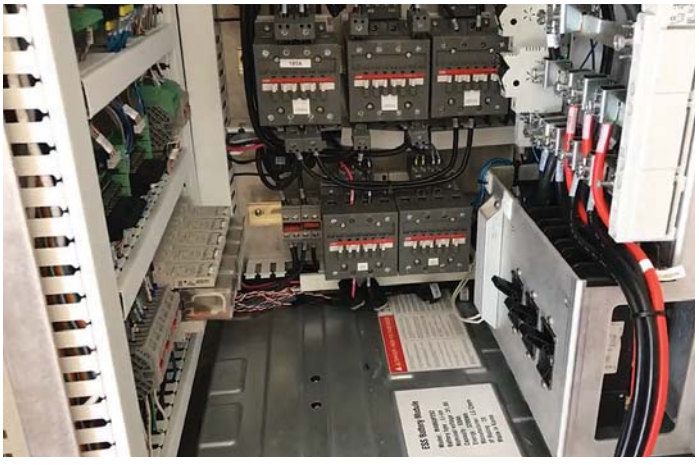
Collecting Data

During the demonstration period, Pecan Street collected operational data from Energy Switches installed in residential structures and existing external data collection systems. The operation was so seamless that during the NREL validation, the visiting engineer did not realize Pecan Street staff had disconnected the structure from the grid for at least 45 minutes. He realized that only when he went to throw the service disconnect switch and spotted it was in the off position. Pecan Street and NREL staff had been inside the house on a hot 90-degree day and had not noticed so much as a flicker when the Pecan Street master electrician had thrown the switch outside.

The Energy Switch was designed to turn an unreliable generation resource, something that requires close attention by a utility for proper integration, into a much more beneficial load on the system. Instead of a perceived detriment to grid reliability, the goal of the program was a system that would turn solar PV into a strong benefit to the overall distribution grid. Ultimately these features would allow solar to provide a tremendous amount of synthetic inertia, congestion management and overall added reliability to the grid, far in excess of what smart inverters can do alone.

As an example, the Energy Switch was configured to limit grid draw to 3 kW, grid sell to 2 kW and perform full-time power factor correction. The figure shows the data collected for two consecutive days. The residential structure without the Energy Switch in operation peaked at 6 kW and had many data points at low overall total power factor. With the Energy Switch operating in a totally autonomous mode, the overall improvement of power factor and demand is clearly shown.

Pecan Street provides access to the world's best data on residential energy and water consumption, testing and verification of technology solutions, and a demonstration testbed platform to help bring breakthrough ideas to market faster and guide policy decisions. Pecan Street's research addresses technology, behavior and how the two interact. The real-world testbed of volunteer research participants the company established in 2010 is the first of its kind and has become an international model for how to develop and conduct energy and resource research and product testing.



A view of the inside of the Energy Switch. It can support black start through multiple behaviors, including immediate reconnect and generation, or delayed reconnection maintaining residential power throughout the blackout.

Each day, Pecan Street collects real power, apparent power, phase angle, distortion and current from up to 24 circuits in a single-family home—all at a one-second interval resolution with near revenue grade metrology equipment. That means a single-family home can generate 10.36 million data points of electricity data per day. Add to that 4-oz. resolution water data, natural gas data and other sources of data, and Pecan Street collects approximately 4.5 billion data points daily.

The Energy Switch is not Pecan Street's only experience with energy storage. As part of a DOE program and in conjunction with Austin Energy, the organization serves as an aggregator for a small fleet of fixed and V2G resources. Next time, the focus will be on some of the lessons learned from that program and some of the areas Pecan Street is looking at using advance smart inverter functions combined with distributed IoT technologies and AI to provide some of the benefits of Energy Switch at a lower cost. TDW

Scott Hinson (shinson@pecanstreet.org) is the chief technology officer and leads activities and electrical research at Pecan Street, a nonprofit research group founded by the University of Texas to provide data-intensive research support to applied research focused on the utility sectors. Pecan Street's work includes operating a permanent research testbed of approximately 1000 houses and apartments in which instrumentation installed and operated by Pecan Street measures minute-interval electricity-use down to the appliance level. Prior to joining Pecan Street, Scott worked at a thin film CIGS solar module manufacturer, where he led module packaging, performance, certification and reliability efforts. He also worked in the military, medical, consumer and oil industries, developing power supplies, precision measurement equipment and inductive heating technologies.

For more information:
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Customized Approach to Cybersecurity

Japanese electric power utilities establish unique strategies on cybersecurity.

By **Tadashi Okabe**, TEPCO Power Grid Inc., and **Tatsuya Tashiro**, **Tomohiro Kan** and **Youhei Okunishi**, Kyushu Electric Power Co. Inc.

With the growing number of security threats to electric power utilities worldwide, in Japan, the requirements for cybersecurity measures on power control systems now are subject to legislation, which has resulted in an increase in efforts to maintain system security. In 2016, security guidelines for electric power utilities were published in a 32-page document, "Power Control System Security Guidelines (JESC Z0004)," which now forms part of the Japanese regulations. All Japanese utilities must follow the national guidelines, designed to maintain reliable and secure operation of power control and information systems.

Using the International Organization for Standardization's ISO27001:2013 and ISO27002:2013 information security management standards as a reference, Japan's guidelines provide a brief description of items that require security measures, including administrative, technical and physical requirements. Unlike the North American Electric Reliability Corporation's Critical Infrastructure Protection standards, Japan's guidelines do not specify how to provide security. Rather, Japanese utilities can select the most appropriate security measures for their power control and information systems in the most cost-effective way.

TEPCO Power Grid Inc. (TEPCO PG) and Kyushu Electric Power Co. Inc. (Kyushu EPCO) are two such utilities that have developed unique security strategies, in compliance with Japan's guidelines, to meet their specific needs.

System Characteristics

A utility should be completely aware of the typical characteristics of operational technology (OT) systems when establishing security strategies for power control systems. Typical characteristics of power control systems are as follows:

- Load dispatch, transmission, distribution and substation management power control systems are so specialized and sophisticated that each system is managed independently by various departments in the utility.
- Endangerment to safety and disruption of power supply are critical risks. Security controls must never degrade the safety and availability of power supply.
- Security patch management is technically difficult because each power control system is isolated from other networks. Therefore, if a security patch is deployed, secure outside connectivity should be provided.
- Power control systems have a large variety and quantity of system components over a wide geographical area. Unlike information technology (IT) systems, OT systems and network components are widely distributed. Because of this, asset management, system configuration management, physical security management, security threat analysis and detecting cyberattacks can be much more difficult.
- A primary target of attack on an OT system could result in an operation malfunction or physical damage but not necessarily confidential data being stolen, as is the case with IT systems. However, these problems can occur often because of accidental equipment failure or maintenance work. Power control system security monitoring must quickly identify whether the problem is the result of a failure, maintenance or a security incident.
- System operation expertise is vital for security response, as it is important to detect suspicious behavior in operations and transactions.

Security Strategies

Strong security strategies for power control require a security governing structure, such as a centralized computer security incident response team comprising power control system experts who can differentiate an operational error from an accidental failure or a cyberattack.

The development of a common security system infrastructure can introduce risks, as the interconnection of various systems has the potential to increase vulnerability and invasion routes. As power control systems vary and are large and geographically widespread, keeping them secure is a challenging task. Fortunately, the risks associated with using IT security products for power control systems have been eliminated now that OT security products are commercially available.

TEPCO PG's Strategy

TEPCO PG is a large Japanese electric utility with many

power control systems, from supply and demand control to energy transmission and distribution, in addition to its systems for data acquisition and business processing. After the Japanese power control system security guidelines were published, TEPCO PG implemented a number of changes in the way it manages security, including establishing a security governing organization, setting in-house security rules, implementing IT and OT integrated security monitoring, developing skill sets and creating cyberattack simulation exercises.

Security Organization

Previously, TEPCO PG had no specialized organization to govern and monitor the security measures in an integrated manner. Security efforts were the responsibility of individual departments. The utility now has two security organizations under the chief information security officer: a security incident response team (SIRT) and the security operations center (SOC).

The establishment of SIRT and SOC has enabled the steady implementation of actions, such as the development of in-house security rules, implementation of the plan-do-check-act (PDCA) cycle of the security plan and development of a response flow in the event of a security incident. For instance, existing power control systems have been checked for conformity to the power control system security guidelines, and penetration tests and detailed risk analysis have been regularly executed for important systems.

With regard to cyberattacks, it is beneficial to share security information among government agencies, the power industry, other infrastructure industries and security vendors. Japanese industry organizations already are involved in these efforts.

In-House Rules

TEPCO PG has made considerable changes to its in-house security rules. The importance levels of power control systems as well as security controls according to these importance levels are documented. The security controls now include technical measures, such as anti-malware, vulnerability information management and log monitoring, as well as physical measures, such as external storage device management, camera monitoring and access control.

Integrated Monitoring

All integrated security monitoring is now conducted by the SOC, which monitors all anomalies detected by several types of security devices. The SOC also monitors power control system logs. In order to handle those logs effectively and efficiently, designing optimal security log feature is one of the key technical issues for future considerations.

NIST's NICE Framework

The National Initiative for Cybersecurity Education (NICE) arm of the U.S. National Institute of Standards and Technology (NIST) published the latest Cybersecurity Workforce Framework (NIST Special Publication 800-181) in August 2017. According to the NIST website, the framework "establishes a taxonomy and common lexicon that describes both cybersecurity work and cybersecurity workers." It is intended for use by the public, private and academic sectors.

The first two versions of the NICE Framework (published in 2012 and 2014, respectively) provided a taxonomy of cybersecurity work categories and specialty areas. The 2017 version refined these and was expanded to include the taxonomy of roles.

In November 2019, NIST announced it will update the NICE Framework again. The public was invited to provide input by Jan. 13, 2020. According to the NICE 2019-2020 winter e-newsletter, "NICE is leading an effort to dynamically maintain the NICE Framework's relevancy, applicability and utility while improving its ongoing alignment with related standards, guidelines and other frameworks. Keeping the NICE Framework relevant is vital to prepare our nation's workforce for increasingly complex cybersecurity challenges."

Security Skills

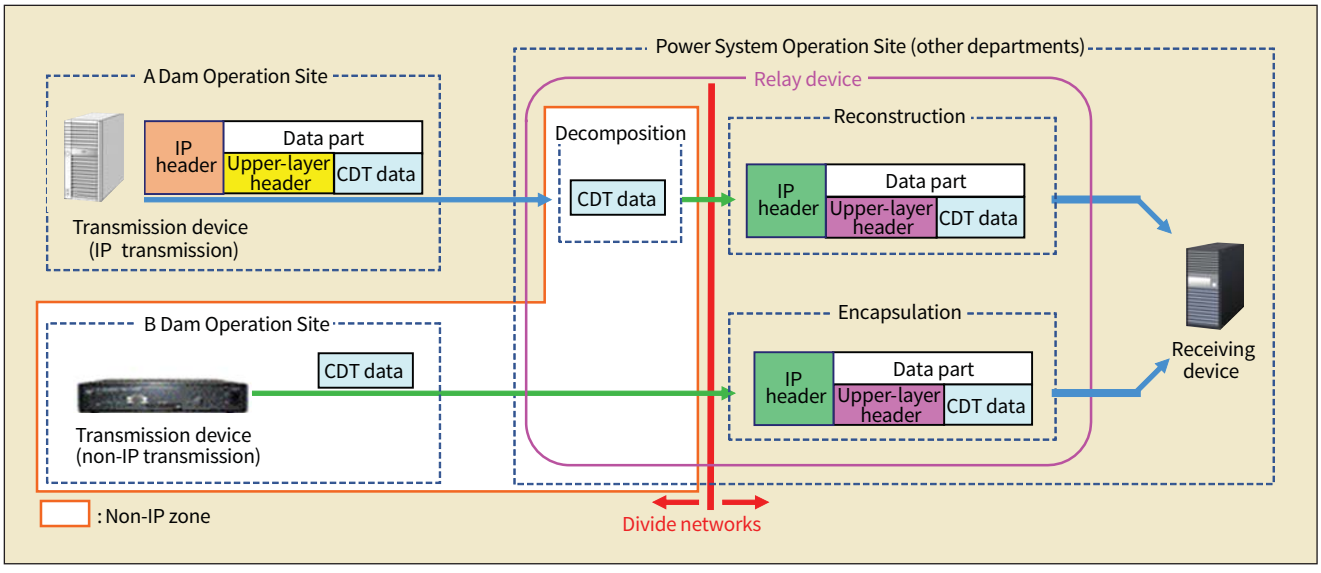
While it is important to assign team members with sophisticated security skills to manage the SIRT and SOC, in the event of a security incident, appropriate assessment of the situation may not be possible without knowledge of how the power control systems operate. Furthermore, it is necessary to under-

stand the log messages that are specialized for each system and to accumulate the knowledge and ability to identify the information necessary for security. TEPCO PG develops the security skills of its in-house power control systems professionals and supplements this with external security experts to handle its detailed security tasks.

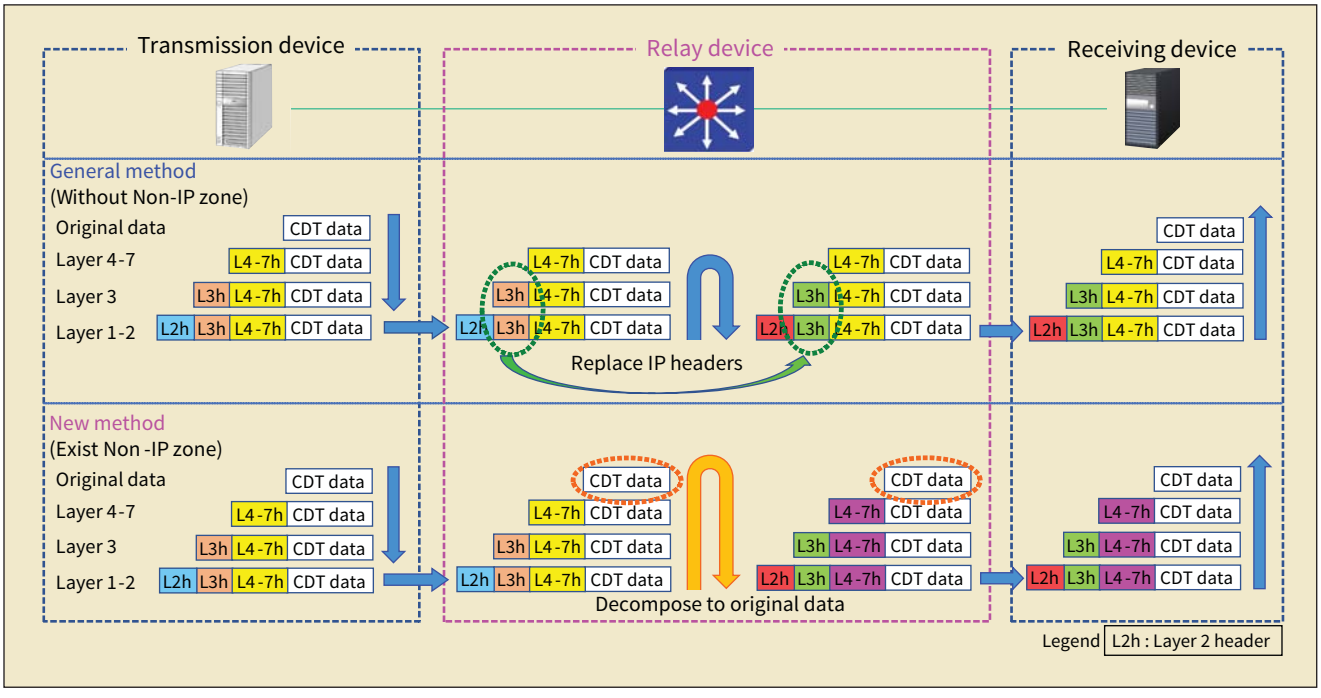
However, the level of security skills necessary for security professionals in utilities is still under discussion. For example, TEPCO PG is not certain its security professionals require skills that would enable them to achieve excellent results at a hacking contest or disassemble hardware and find vulnerable code. However, sophisticated IT security skills certainly are necessary to detect invasions at the reconnaissance steps of an attack and develop strong anti-invasion tools. TEPCO PG currently is trying to develop a skill map using the U.S. National Institute of Standards and Technology's National Initiative for Cybersecurity Education (NICE) Cybersecurity Workforce Framework as a reference.

Simulation Exercises

Many cyberattacks are observed daily in the IT world, but normally this is not the case for power control systems. TEPCO PG's SOC sometimes detects security alarms, but the majority are not a true security incident. Therefore, the utility has found regular cyberattack simulation exercises are a good way to prepare for real attacks. Some of the simulations are conducted



Security system configuration adopted by Kyushu EPCO.



Open system interconnection reference model.

without giving team members advance notice.

Team members from a wide range of functional areas across the enterprise participate in the simulations, including leadership, SIRT, SOC, system operators and public relations, depending on the scenario. By conducting and designing various simulation exercises, the inherent problems of current response flow can be identified.

Kyushu EPCO's Strategy

Another Japanese utility, Kyushu EPCO provides power to seven prefectures, or subregions, of Japan. Much like TEPCO PG, this utility also changed its organization structure. Kyushu EPCO established a dedicated organization to monitor its information systems.

Information necessary to the operation of its power system is transmitted from hydro plant dam operation sites to the power system operation site. This information includes the water volume discharged by the power generation dams and their water level as well as the updating of the dam management systems.

The utility has been shifting its communication method from the conventional cyclic data transfer (CDT) method to the internet protocol (IP) method. The CDT systems require relatively expensive dedicated transmission devices. With the IP method, cost is reduced because the network can be constructed using general-purpose devices. If the IP network already is in place, the cost for construction can be even less. Converting the communication method to the IP network enables usage of the existing IP network and general-purpose network equipment when constructing new networks, resulting in a reduction of the construction costs of the transmission system.

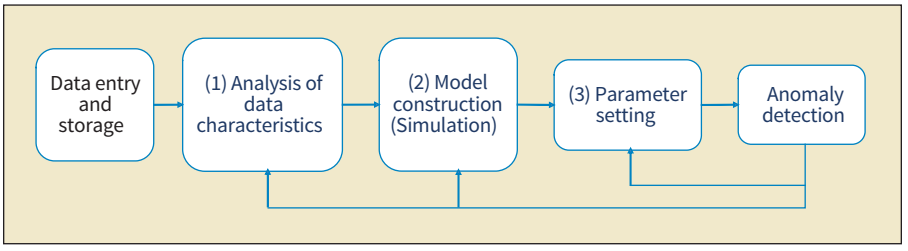
On the other hand, IP migration creates the need to consider defense against cyberattacks, such as unauthorized accesses and intrusions of malwares into the network. Specifically, the propagation of cyberattacks occurring in certain networks to the power control systems connected to the network can cause serious problems, such as the trouble to supply power to customers.

Furthermore, the dam operation site and power system operation site are important issues in the IP migration of the dam management system.

Kyushu EPCO adopted a method to decompose the IP format to the original data and reconstruct the data to a new IP format using a relay device installed at the boundary between the different networks. This method makes it possible to separate the different networks logically, preventing security incidents in other networks from spreading to the connected network.

As a result of adopting this method, the utility remodeled the relay devices to translate CDT format and IP format to the

same IP format. The data is transmitted to the receiving device at the power system operation site. General transmission methods of IP format data replace IP headers with relay devices, such as routers. In this case, different IP networks are connected by the relay devices.



Anomaly detection process.

The relay devices are used to decompose the IP format data received from the transmitting device to the CDT format data. The CDT format data passes into the internal bus, and the new IP format data is reconstructed from the CDT format data. Finally, the IP format data is transmitted to the receiving device. As a result, the data can be exchanged between different networks while being separated as IP networks.

In accordance with Japan's control system security guidelines, a proprietary non-IP is adopted at the connection point between different networks. Hence, Kyushu EPCO has ensured its IP network security complies with the country's security guidelines.

Machine Learning

The utility collects information on the performance of all its servers and communication devices at regular intervals to monitor its information systems. For important information, thresholds are set and any collected data that exceeds these thresholds is detected and recorded as an anomaly.

With the aim of improving the level of operation in the future, Kyushu EPCO has conducted verification to determine the feasibility of early detection and prevention of failures by monitoring using machine learning.

Failure Monitoring

The current anomaly detection mechanism is designed to issue an alert when specific software goes down or the load applied to a server exceeds the preset threshold. However, in some cases, this mechanism is unable to detect failures only by means such as threshold monitoring and alive monitoring, resulting in a delayed response.

To address this problem, failure monitoring using machine learning constructs a model, by analyzing data characteristics based on the data acquired during the normal state, to detect deviations from the model. Failure monitoring enables the utility to detect and perform predictive analysis of anomalies that cannot be detected by threshold monitoring.

Anomaly Detection Process

To achieve anomaly detection using machine learning, a process comprising data entry and analysis, model construction and parameter setting is performed according to the following flow process:

- Data stored in the past is used to analyze whether or not target data has characteristics (periodicity, normality and correlation) that can be used for the detection of anomalies.
- Characteristics identified by the analysis are used to select an algorithm for determination of whether the data is normal or abnormal.
- Parameters of the selected algorithm are set to increase the accuracy of anomaly determination.

Verification

Verification is conducted to determine whether the failure monitoring system, using machine learning, enables early detection when communication device failures occur. If the results of the analysis of data characteristics reveal that the traffic data from a communication acquired during the learning period has period characteristics, a model is constructed based on those period characteristics, thereby enabling the detection of the collapse of the period characteristics immediately before a failure occurs.

Although failures were detected during the verification process, the failure detection took place immediately before the failure occurred; hence, it failed to achieve predictive detection. In the future, the algorithm parameters will need to be reviewed so failure predictions can be detected earlier.

Refining Security Strategies

TEPCO PG and Kyushu EPCO are examples of utilities that have developed unique security strategies specific to their operational needs. The utilities will continue to refine their strategies to protect against the growing number of security threats while ensuring compliance with Japan's guidelines. TDW

Tadashi Okabe has an M.Phil. Degree from the University of Essex in the UK and an M. Eng. Degree from the Sophia University in Japan is a specialist and security evangelist at TEPCO Power Grid, Inc. He is responsible for advising on technical aspects of TEPCO PG's IT and OT systems, system security and communication network, including TEPCO PG's 30 million smart meters AMI system.

Tatsuya Tashiro is an engineer responsible for information and communication systems at Kyushu Electric Power Co. Inc. Currently he is working at the QTnet, Inc. which provides communication, cloud and data center services.

Tomohiro Kan is an engineer in the Information and Communication Department at Kyushu Electric Power Co. Inc. His responsibilities include monitoring the operation of the system used by the company.

Youhei Okunishi is in the Service Solution Department at Kyuden Business Solutions Co.Inc working on the design and building of monitoring systems.

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Workers being introduced to the new CLP at the National Grid Academy in June.

Rethinking Reconductoring

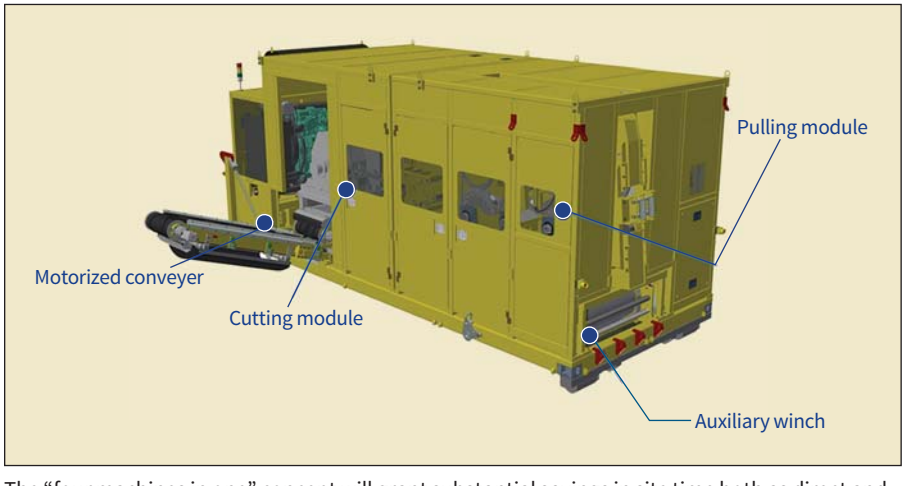
New concept for continuous line pulling will help keep outage work to a minimum.

By **Doug Galloway**, National Grid Electricity Transmission plc, and **Alberto Oscar**, Tesmec SpA

Transmission system operators are required to provide customers with continuous power. To maintain such a high standard of reliability, operators must plan repair schedules to ensure equipment and assets are well maintained and in full working order.

Every transmission system operator has to make numerous repairs to the network each year and, as a direct result, must manage a series of planned outages, or deenergization, of numerous circuits to facilitate this maintenance work. During an outage period, the network must be reconfigured temporarily, which may also affect the vulnerability of the supply.

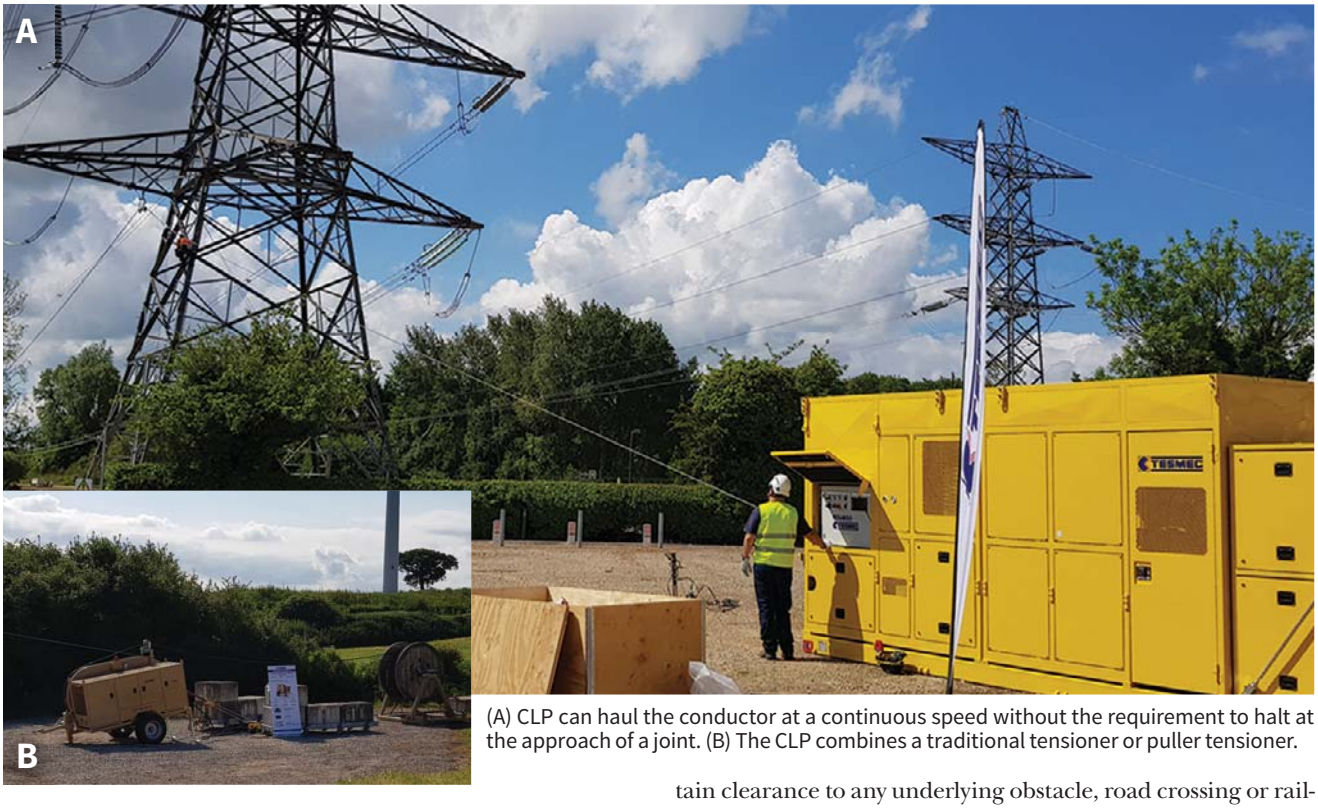
Therefore, it is extremely important outage work be kept to an absolute minimum. The continuous linear puller (CLP) is a new concept developed by a collaboration between National Grid Electricity Transmission plc and Tesmec SpA for replacing overhead line (OHL) conductors. Conventional machinery, although much improved, has not fundamentally changed, since its introduction over 50 years ago.



The "four machines in one" concept will grant substantial savings in site time both as direct and indirect costs.

The Current Method

The current method for replacing OHL conductors involves a puller and a tensioner or, more commonly, a two puller-tensioner. The method entails attaching a new conductor to the existing conductor, placing conductor blocks at each intermediate structure, winching in the existing



(A) CLP can haul the conductor at a continuous speed without the requirement to halt at the approach of a joint. (B) The CLP combines a traditional tensioner or puller tensioner.

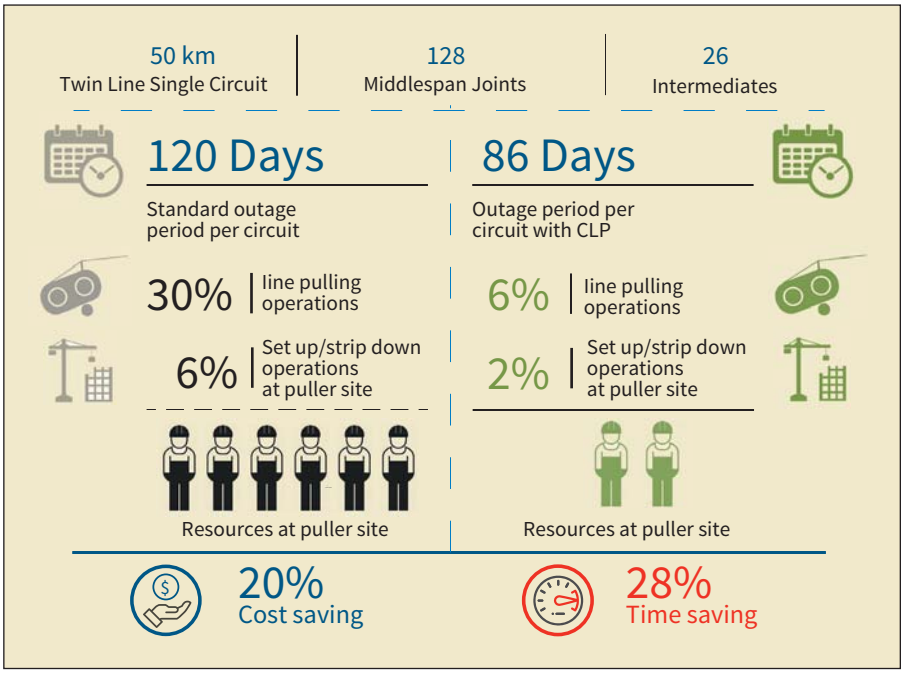
conductor and then coiling it onto an old drum. New conductor is fed in by a factory wound drum, reeved around a large tensioner and then released at a continuous tension to maintain clearance to any underlying obstacle, road crossing or railway infrastructure.

The existing conductor collected onto drums is transported to a recycling facility, where the conductor strands are separated

so as not to mix the steel strands with the aluminum. Both these products then are processed into reusable material.

The existing machines designed to pull the old conductor must stop each time a joint in the old conductor arrives at the puller. This joint may be one of the following:

- Existing mid-span splices installed during the main conductor construction phase
- Repairs of conductor in areas where the outer strands have been damaged by externally mounted fittings, such as spacers, fittings, etc.
- Repairs where conductor has been struck by lightning and strands may have been broken
- Line diversions and turn-ins where modifications have been made to the network and conductor has been reused
- At every intermediate pull-through tower where tension insulators are replaced with a short section of conductor, four stockings, a C-connector and swivel.



The analysis shows a time saving of 28% with a personnel reduction of 66%.

These joints and connectors are not designed to travel around the surface of the bull wheel on the winch. In fact, the design of the grooves in the outer diameter of the bull wheel is very sensitive to any discrepancy or variation in the circumferential size of a conductor or joint. The passage of joints and connectors around the bull wheels has the potential to damage or break the conductor. Additionally, there is a possibility a joint will get stuck in the bull wheels, which would cause the conductor to sag down, possibly making contact with other lines, buildings or even as far down as the ground.

To avoid the risks, the traditional method implies stopping the winching process on both entry and exit of the machine to connect and remove a temporary joint manually.

On bundled conductor phases, it is worth noting the connectors and joints may not always be aligned; therefore, this entire removal process may be replicated many times during a single conductor pull.

The prior reconductoring technology can be used on anything from 132-kV single conductor up to large-capacity extra-high-voltage networks 220 kV and above, usually in a bundled conductor configuration ranging from two sub-conductors to eight sub-conductors, with drums arranged at the tensioner site and a similar arrangement at the puller site. This requires a considerable area of land and multiple numbers of drum stands to hold the new and old conductor drums; moreover, the project durations will vary tremendously as larger conductors require a disproportionate time to prepare and remove joints.

CLP potentially eliminates the need for EPZ provision.

A New Solution

On June 6, 2019, at National Grid Academy in the UK, a new type of machine, the CLP, was demonstrated for the safe collection and disposal of existing conductor (view the demonstration video at https://youtu.be/spQ0NAU_Iu8). Development of the machine started from an existing proprietary technology used for pulling continuous cables.

The new solution consists of a machine that can pull conductor at a continuous speed without having to halt when a joint or connector approaches. The pulling operation proceeds at a constant pace so as not to stress any intermediate support and retains the tension in the conductor during

the entire process, even when a joint passes through the winching mechanism. Furthermore, the possibility of collecting conductor in a way that is required by the recycling facility, without the need to recover it in separate coils, has been implemented.

This new solution has the potential to provide several cost and time savings over the conventional method:

- Reduction in circuit outage time (circuit de-energized)
- Fewer contract resources required
- Reduction in the amount of temporary platforms (equipotential zones) that need pulling machinery
- Health and safety benefits as a result of fewer operators working heights and substantially fewer tripping hazards
- Environmental savings across the entire operation.

New Machine Concept

The new puller was designed and manufactured with a four-machines-in-one concept:

1. Direct spooling winch located on the front of the machine to assist with conductor loading
2. Self-adjusting pulling module with multiple pinch wheels for self-loading of the conductor that enables joints and connectors to pass without stopping
3. Cutting module to cut the old conductor in small parts, including mid-span joints and similar devices
4. Conveyor system to move the chopped conductor parts into a proper container.

The benefits of the CLP fall into different categories, as some are related to direct costs whereas others are classified as indirect. The largest key benefit is the time reduction in the utility's outage period, because the contractor can perform the refurbishment process in a timely fashion.

Health and safety benefits can be realized due to less operators working at height and substantially less tripping hazards.

A Case Study

The analysis from a case study by National Grid showed substantial savings in site time, both as direct and indirect costs.

The operator has the option of either standing on a designed footplate or operating the machine via radio remote control. The user-friendly HMI of the machine grants optimal performance and simple operations.

The case study, based on 50 km (31 miles) of a double-bundle single circuit with a total of 128 mid-span joints and 26 intermediate joints, generated a 28% time savings, moving from 120 days to 86 days of outage. In breaking down the time savings, 4% was related to setup and strip-down operation at the puller site and 24% to the pulling operation.

The CLP machine also dramatically reduced the personnel levels required at the puller site, from 6 workers to 2 workers, a savings of 66% in labor expense.

New Job Site

The conventional job site setup is different from the CLP setup because of the types of equipment and personnel required on-site for the pulling operation. On a conventional job site, a range of equipment associated with each pulling machine or winch can be found:

- Powered drum stands (two per sub-conductor)
- Kentledge/ballast weights
- Equipotential zone (EPZ) to support all the machinery

This equipment is used as follows:

- A truck delivers and installs the EPZ as required, depending on the size of the winch and number of drum stands.
- Drum stands and kentledge weights are delivered onto the EPZ and then assembled by the site operatives.
- Drums of coiled scrap conductor are either removed one at a time by truck or tractor and taken back to the depot or are stored on-site and removed by a large truck.

The job site for the CLP may not require any other supplementary equipment apart from the removal of scrap conductor; hence, there is a variation in the number of delivery vehicles that have to travel to the job site to deliver and collect these items of equipment.

In the conventional stringing process, to set up the site, old drums are placed at the puller for scrap conductor and removal requires multiple visits to the site by a truck or tractor, complete with a hydraulic lifting arm. The CLP can reduce the frequency of truck visits because the machine is self-contained and only requires a suitable container to collect the scrap conductor. Site access restrictions require rigorous planning to ensure the scrap conductor is handled efficiently.

The CLP is designed to eradicate the need for conventional take-up drum stands. Instead of drum stands, a large waste disposal container is required to collect all the small pieces of used conductor from the CLP that are dispensed by the conveyor.

Associated with the process of removing the joints prior to entering the machine, the CLP is a continuous process and, thereby, does not require the use of the equipment that temporarily takes the tension of the conductor while the joints are being removed.

Safety and the Environment

The CLP also eliminates the need to have personnel working heights, thus improving operational safety. It is planned to replace the conventional method of connecting two sections of conductor with a novel connector that can be installed by the operatives as simply as the conventional equipment. This enables joints and connectors to pass through the CLP without

A new type of machine has been developed from Tesmec's existing proprietary technology used for pulling continuous cable.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This self-contained machine reduces the frequency of truck visits and only requires a suitable container to collect the scrap conductor (left), The CLP has been designed to collect dust particles of aluminium oxide during the recovery of the conductor and remove them at source (right).

stopping; hence, they are classified as consumables.

The CLP potentially eliminates the need for the EPZ provision. The purpose of the EPZ is to connect all parts that may be accessed by operators in the event that, with an unplanned reenergization, all items rise to the same voltage level. The CLP processes conductor without the need for the collection of conductors onto drums, resulting in operators not having to come into contact with conductors. Operators have the option of either standing on a designated footplate or operating the machine by radio remote control and being nearby the machine but not in direct contact.

The new process also introduces a new environmental feature. The traditional process of recovering aged conductor often can generate many particles of aluminum oxide that, in certain conditions, can cause potential issues for site personnel, the area around the machine and the actual pulling machinery, as these particles are very abrasive. The CLP device has been designed to collect these dust particles during the recovery of the conductor and remove them at the source, so particles do not become airborne.

The Next Evolution

The newly developed CLP is a proven concept for the replacement of OHL conductors in the energy sector. The CLP machine can be complemented by new items to potentially introduce further advancements from the conventional tension stringing system, moving from the CLP to the continuous pulling system (CPS). New stringing concepts currently are in the feasibility evolution and prototype phase to provide even further benefits:

- Minimize the pulling tension value to prevent conductor damages.
- Maximize the collection of scrap conductor.
- Minimize dead time at the tensioner station when replacing old reel with new reel of conductor.
- Minimize the time of execution of mid-span joints or temporary connections.
- Minimize the clipping operation time after the stringing operation. TDW

Doug Galloway (doug.galloway@nationalgrid.com) is the circuits technical leader for National Grid Electricity Transmission plc in the UK. He leads the utility's technical strategy and direction for overhead line and cable technologies. With more than 30 years of experience in the industry, mostly on the contractor side, Galloway moved to the client side more than six years ago and has been in this role for two years. He is a chartered engineer and member of the Institute of Engineering and Technology (IET).

Alberto Oscar (alberto.oscar@tesmec.com) is chief technology officer of the stringing division at Tesmec SpA in Italy, where he leads a large team of research and development engineers involved in the design and manufacturing of T&D overhead and underground power line stringing machine and equipment. He has a degree in mechanical engineering from Politecnico Milan, Italy, in 1988. He is an active member of the Commission Electrotechnique Internationale/International Technical Commission (CEI/IEC) TC 11 Overhead Lines, TC 78 Live Working (WG 11 Technical Support) and TC 20 Electric Cables; CIGRE SC B2 Overhead Lines (WG B2.66 Safe Handling and Installation Guide for High-Temperature Low-Sag Conductors); and IEEE.

For more information:
National Grid Transmission plc | www.nationalgrid.com
Tesmec SpA | www.tesmec.com

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Penn Power Hardens System

Safety Talk

Metallic Balloons Spark Power Outages

When balloons are removed from power lines, they can explode, endangering field workers.

By **Paul Netter**, Southern California Edison

The lettered metallic balloons were stacked perhaps 10-ft tall, the troubleman removing them from power lines was 5 ft 8. And the continuing problem? Well, it's much bigger than either of them.

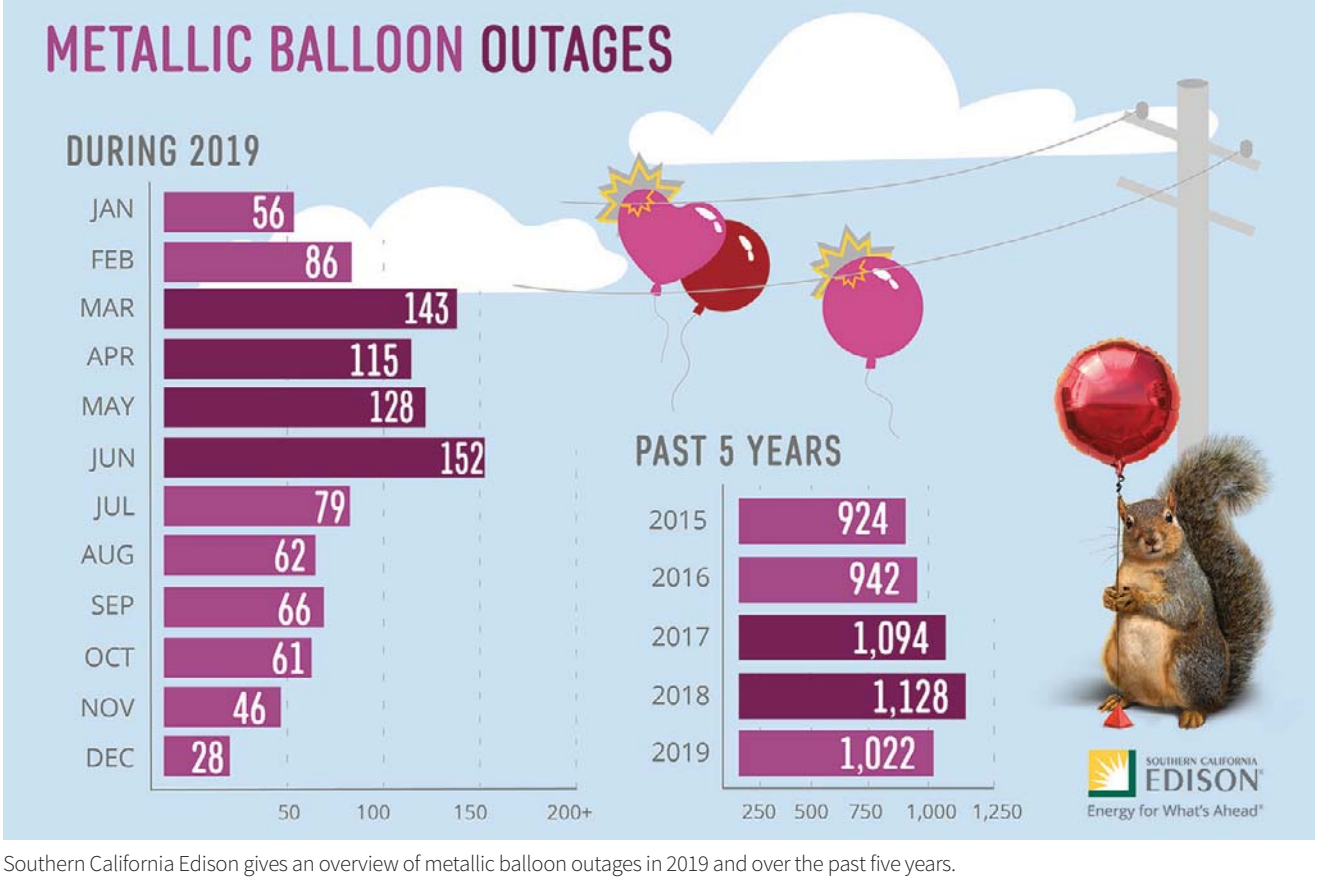
Southern California Edison experienced 1,022 outages caused by metallic balloons last year, affecting 1.07 million customers and leading to 2,123 hours of lost power — a slight dip from the previous two years but still the third-most outages ever.

Valentine's Day leads to a spike in the popularity of the colorful gifts that in turn triggers a sharp increase in balloon-related outages that typically doesn't peak until June's graduations. SCE troublemen like Jeff Seale are ready to protect critical needs like medical facilities and traffic lights by removing them from power lines and equipment, whether they're like the 10-footer he vividly recalls or smaller.

"I remove metallic balloons from power lines a couple times a week or nearly every other day," said Seale, a 30-year SCE employee who has been a troubleman for 25 years. "People are pretty used to calling in when they see them. I'd say maybe a quarter of them are old and deflated, but, more often than not, it's a fresh one floating away that got stuck or one coming down."

That "fresh one floating away" or "coming down" is the crux of a lingering problem with a simple solution.

"Never, ever, release metallic balloons outdoors and always



Southern California Edison gives an overview of metallic balloon outages in 2019 and over the past five years.

secure them to a weight, as required by state law, or something else sturdy like a table," said Andrew Martinez, SCE vice president of Safety, Security & Business Resiliency. "Keep them indoors, if possible, but releasing them into the air can threaten public safety."

This is a problem that Seale knows firsthand from his patrols of the San Gabriel Valley.

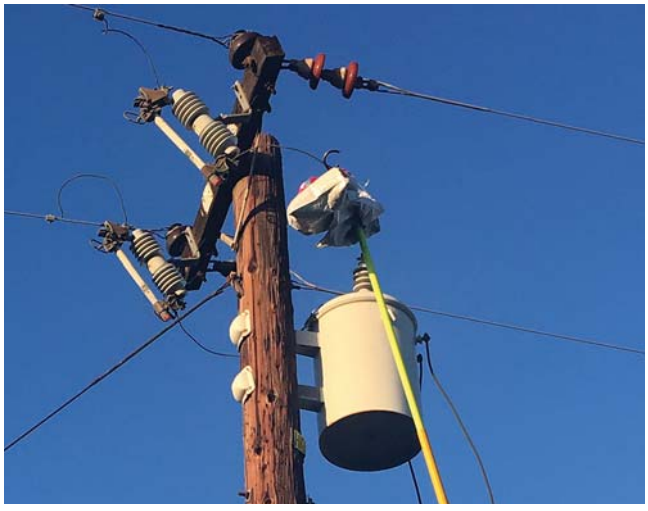
"More often than not, I'm responding to an outage or wire down as a result of a balloon that blew up," he said.

Facing Hazards

Such balloon explosions can have serious consequences, especially when they bring down power lines as they did 98 times last year, potentially leading to serious injuries and property damage. SCE reminds customers to stay away and call 911 if they ever see downed lines.

As for the consequences, they also apply to workers like Seale, who deploy electrically insulated tools to remove the balloons. It is not uncommon for the balloons, often shifting in the wind, to explode above or near utility workers preparing to remove them.

Because of the safety threat, easily avoided outages and dramatic increase in those outages every February, SCE continues its territory-wide safety campaign to educate customers about the hazards of released metallic balloons, downed power lines and more.



The balloons' metallic coating is the conductor that leads to short circuits, outages and sometimes downed power lines.

And, of course, it's the balloons that Seale encounters most.

"I think tree branches and palm fronds are the second-most prevalent, but they are typically more associated with a wind event," said Seale. "I think the balloons are a regular occurrence and the easiest to prevent." TDW

Paul Netter is an "Energized by Edison" writer for Southern California Edison.

Penn Power Hardens System to Boost Reliability

Field workers inspected equipment, performed proactive maintenance and installed new equipment to curb weather-related outages.

By **Jeff Doran** and **Lauren Siburkis**, Penn Power

Winter storms have the potential to cause damage to poles, wires and substations, requiring crews to make repairs in difficult conditions. The weight of wet snow and ice can put extra stress on the system as well as on trees and other structures that can impact equipment.

By completing this work ahead of the recent winter season, Penn Power strengthened its electric system and kept the lights on for customers when they depended on it the most to stay warm and comfortable. Each year, Penn Power prepares for winter by conducting inspections and equipment maintenance on weather-sensitive equipment across its service area. Completing inspections and maintenance of equipment during the summer and fall can help enhance system resiliency to keep power flowing to customers when severe winter weather strikes.

The work includes the use of special thermal-imaging cameras to detect hot spots, or weak points, invisible to the naked eye on electrical equipment prone to overheating and malfunctioning as customers crank up their heaters to combat the cold. Substation electricians also inspected batteries used to power relays that sense faults on the network and motors that automatically operate switches to isolate those problems, helping to prevent service interruptions or limit their size and scope.

In the fall of 2019, Penn Power proactively replaced more than 184,000 ft of power lines with thicker, durable wire designed to withstand severe winter elements like ice and heavy, wet snow.

Replacing Power Lines

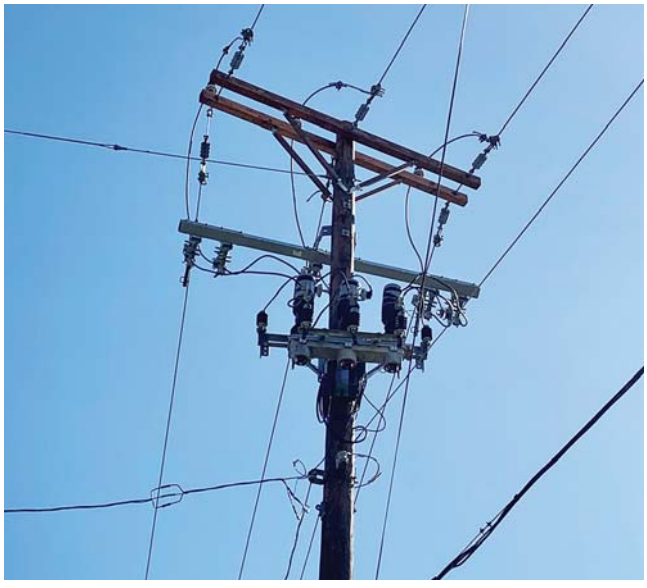
Penn Power distributes the work across its entire internal labor force to give equal training and experience to all of its employees. Setting poles is a job the lineworkers perform every day, but stringing thousands of feet of wire at once is a less common project and very time consuming. For such projects, the company oftentimes hires contractor crews to assist in completing the work ahead of schedule. These projects are prime situations for training exposure, and they allow the younger lineworkers to gain experience from the more seasoned employees.

Recently, Penn Power expanded upon its traditional winter readiness work to install about 1,000 new poles and replace more than 184,000-feet of power lines with thicker, durable wire designed to withstand severe winter elements like ice and heavy, wet snow.

This type of wire has been used in the past by each of FirstEnergy's 10 electric companies, including Penn Power. As energy demand increases each year, the company's electric system must also be updated to be able to safely provide customers with the power they require.

The more resilient wire offers many different benefits for customers. The larger wire allows for a higher ampacity rating in times of the year when the system is experiencing higher demand, such as the summer and winter months. It also allows the company to use circuit tying capabilities between substations. This is vitally important during peak seasons to help evenly distribute load across the system.

The circuit tying also comes into play during an emergency, such as when a tree falls onto wires or when a car hits a pole. Penn Power will now be able to iso-



In 2019, Penn Power installed more than 70 Elastimold automated reclosing devices to enhance service reliability for customers in rural areas.

late the faulted section of the system and temporarily pull the needed power from other sources until repairs are completed. This keeps as many customers in power as possible during unexpected outages.

The wire is installed the same way as other conductors, just using larger more heavy-duty equipment and materials to support the increased weights.

Rolling Out Reclosers

In addition, lineworkers installed 72 new automated reclosing devices on three-phase power lines to help restore power to customers within seconds in the event of a power outage and significantly reduce the length of an outage.

Penn Power is already seeing the benefits of the reclosers' capabilities. Not only do they help in the isolation and restoration of unforeseen power outages, they are providing added benefits to Penn Power's normal day-to-day operations.

Penn Power also spent the latter part of 2019 installing 120 new automated reclosing devices on single-phase power lines to help limit the frequency and duration of service interruptions. The electrical device works like a circuit breaker in a home with the added benefit of automatically re-energizing a power line within seconds to keep power safely flowing to customers.

To determine the best locations for these devices, utility personnel reviewed outage patterns across Penn Power's service area and identified outage-prone areas that would benefit from an automated reclosing device. Although most of the work completed in 2019 was concentrated in one particular area within Penn Power's service territory, the project was a preview of what's to come over the next five years across the entire Penn Power footprint.

Installing the Devices

Before the reclosers, switching operations on the electric system required a truck to drive out to each location to perform physical switching on the equipment. This can now be performed with the push of a few buttons by an operator inside of the Distribution Control Center (DCC). The installation of new automated reclosing devices and creation of new circuit ties will isolate outages to a smaller number of areas and significantly reduce the length of an outage.

When installing the new reclosers, Penn Power's lineworkers start by replacing the pole in order to gain height and stability. The conductors are then transferred and dead-ended on each side of the new pole while maintaining a physical break between the two ends of the wire. Next, they install a fiberglass unitized switch arm that contains three separate switches on it. Each switch contains three blades — a source side blade (the direction the power is normally fed from), a load side blade (the wire that is being fed from the source side) and a bypass blade. The bypass blade would be used if the recloser would need to be taken offline and power was still required to flow through that location.

Workers then install the actual recloser, wiring it to the unitized switch arm installed above. The switches are wired onto the conductors previously dead ended on either side of the pole. A communication cable is ran from the recloser to the bottom of the pole where it attaches to an electronic control box. This control box allows an employee to control the recloser from the actual site location or via the SCADA system from the company's DCC. The final step involves a combined effort of Penn Power's engineering, substation, overhead lines, communications and DCC groups to test the recloser. Once all tests are passed, it is put into service and released for daily operations.

The company prepares for the installation of these devices by conducting hands-on training classes in line shops for field personnel. By setting up a mock demo of the control boxes, it allows employees to familiarize themselves with the control

Penn Power customers will benefit from installation of 72 new automated reclosing devices that can help restore power to customers within seconds in the event of a power outage and significantly reduce the length of an outage.

Penn Power lineworker Alex Greathouse installs an automated reclosing device on a single-phase power line in western Pennsylvania.

panel and the different buttons and codes they may come across. Penn Power began slowly by sending out its most experienced lineworkers to install the first recloser. As confidence grew, the company spread out the work across more resources and share the knowledge gained during the initial installations.

Investing in the System

This work was part of Penn Power's 2016-2020 Long-Term Infrastructure Improvement Plan (LTIIP), approved by the Pennsylvania Public Utility Commission to help enhance electric service for customers. On Aug. 30, 2019, FirstEnergy's four Pennsylvania utilities filed the proposed 2020-2024 LTIIP with the Pennsylvania Public Utility Commission outlining investments of $572 million over the next four years to accelerate infrastructure improvements and enhance service reliability for more than 2 million customers in the state. The 2020-2024 plan was approved in January. Under this plan, Penn Power is slated to make $72 million in investments to enhance electric service reliability for its more than 160,000 customers in western Pennsylvania.

These investments build on earlier improvement plans with targeted projects designed to reduce the frequency of electric service interruptions for customers and shorten the duration of outages when they do occur. Major initiatives will include replacing older infrastructure with new poles, overhead lines, underground cables, substation equipment, network vaults and manholes; reconfiguring circuits to minimize customers impacted by service interruptions and installing more advanced "smart" devices that can detect and isolate problems to help quickly restore power to impacted customers.

Another major reliability project Penn Power completed in 2019 is the installation of new interior fencing in substations to help deter climbing animals and protect against electrical equipment interference that can cause power outages. The fencing — installed inside of a substation around the perimeter of the equipment — keeps the animals out of harm's way and the electricity safely flowing to customers. The company plans to install additional animal deterrent substation fencing at other substations over the next five years.

Penn Power customers will benefit from installation of new automated reclosing devices that can help restore power to customers within seconds in the event of a power outage and significantly reduce the length of an outage.

Climbing animals present one of the greatest threats to substation operation and electric service reliability. A single substation outage can cost thousands of dollars in equipment damage and hundreds of man hours to repair as well as causing extended outages for customers served by that circuit. The special fencing was an economical solution to prevent these types of service disruptions in the future.

Unlike other types of animal traps and deterrents, this special fencing completely prevents climbing animals from accessing the substation equipment and discourages them from trying again. Many climbing animals, like squirrels, have a highly developed memory that enables them to remember locations for food, warmth and shelter. With one brief contact with a fence panel, animals learn that a substation is not a welcoming location to visit and typically avoid protected substations in the future. This fencing has proven to be successful for Penn Power's sister utility in Maryland, which has seen a sharp decline in substation outages due to animals.

Through these proactive measures, FirstEnergy is able to protect its system not only in the winter, but also year-round to minimize outages and improve reliability. TDW

Jeff Doran (jdoran@firstenergycorp.com) is the operations manager at Penn Power.

Lauren Siburkis (lsiburkis@firstenergycorp.com) is the external communications representative at FirstEnergy.

Life Line

Donald Putnam

Ameren Illinois

- Born in Litchfield, Illinois, and has three brothers and two sisters.
- Married to his wife, Kimberly, for the last eight years. They have three sons: seven-year-old Asher, five-year-old Emmett and two-year-old Baylor. His family also has three miniature Schnauzers.
- His twin brother, Daniel, and brother-in-law, Garrett Young, are linemen in the shop where he currently works.
- Enjoys trying new restaurants and traveling with his wife. He also likes hunting and gambling.

Putnam is thankful that he knows how to perform hurtman rescue after having to rescue his pole buddy.

Early Years

When I was 26, I was working in a factory and decided I needed to learn a skill. I signed up for a line apprentice training school that winter. After I graduated, I started working out of Local 175 in Chattanooga, Tennessee. I served as an apprentice on a barehand crew for Henkels & McCoy. I traveled through Alabama, maintaining switches and changing high-priority transmission poles while energized.

Day in the Life

I'm currently a journeyman lineman with Ameren Illinois. My responsibilities would be to watch out for my brothers and teach the apprentices safe work practices. My typical workday could range from troubleshooting to new installation of underground/overhead conductors on a crew.

I am currently working on a single-phase extension to feed a new Dollar General. Ameren Illinois is always working on keeping up to date with hardening its system with smart meters, voltage optimization and routine maintenance.

Challenges and Rewards

The biggest challenge with working in the utility field is finding a balance of work and life outside of work. The reward of restoring power to people after a major storm is always best — whether it's a three-phase-line or just a house service, most customers are grateful.

Tools and Technology

I can't live without battery-operated tools including drills, cutters and presses. I also recently installed a bucket knuckle in my truck to hang all my tools. It's been nice not having to pick everything off the floor of the bucket each time I need to go up.

Safety Lesson

My bucket truck, which was parked on the side of the road, was struck by a drunk driver back in 2015. I learned never to turn your back on traffic or think every driver is at full attention. I also had to perform pole-top rescue on my pole buddy in 2014. We were working a secondary open wire dead-end pole, transferring open wire to the new pole from our hooks in the backyard. He made accidental contact above his secondary gloves with a hot leg and became locked onto the phase. I had to knock him off the wire and he went unconscious. My crew and I started pole-top rescue and lowered him to the ground. Once he made contact with the ground, he regained consciousness and was transported to a local hospital for kidney failure.

I never thought in a million years that I would actually have to perform a rescue. I wouldn't want to wish that on anyone, but am very thankful to be trained to do it. We have to be re-certified every year to do a hurtman rescue. Even though it is repetitive, I am happy to know how to do it.

Memorable Storm

My most memorable storm of all was while I worked for Tennessee Valley Authority. During the "Day of Devastation," strong storms rolled through the south. I believed the valley had around 150 transmission towers down. We worked long hours getting back critical lines putting up 500 kV towers.

My most memorable Ameren Illinois storm was July 2015. Straight-line winds (clocked at 74 mph) blew into town around 6 p.m. The winds blew down trees all over Quincy, Illinois. There was a lot of damage to individual homes, and I worked the restoration efforts for three days. My parents are from Quincy, and my aunts, uncles and cousins still live in the city. There was a great sense of pride restoring service to my family.

Future Plans

I would go into the power industry if I had to start over again, but I wouldn't like to come in much younger than I did. TDW

Attention linemen: Do you know of a lineman who we could profile in a future Lifeline department? Email Field Editor Amy Fischbach at amyfischbach@gmail.com with his or her name, title, company name and years of experience as well as what makes him or her stand out from the crew.

Parting Shot

Photo by **Sean Daly** of National Grid

This photo of National Grid linemen working a storm in New York won first place in the 2020 Lineman Life photography contest. To see the top 10 photos in the competition, visit the Electric Utility Operations Web site at www.tdworld.com/electric-utility-operations.

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ComEd Vice President of Engineering and Smart Grid Shay Bahramirad reviews a student project.

Professionals Mentor Tomorrow's Workforce

ComEd's STEM education strategy enables students to learn key engineering concepts while partnering with professionals in the field.

By **Aleksi Paaso**, **Daniel Kushner**, and **William Hanigan**, Commonwealth Edison Co.

With the increasing threats of climate change and cybersecurity, electric utility engineers today need to protect the existing grid while looking to the future. To transform the power system to become greener, more efficient and more resilient for generations to come, the engineering team of the future needs to be diverse in talent, experience and learning styles. Likewise, the utility of the future needs to hear the diverse needs of the community as it helps established engineers to teach and future engineers to learn.

Today, with exciting technological developments and demand for cleaner energy, Commonwealth Edison Co. (ComEd) is innovating with a sense of urgency while working to inspire a future generation of engineers with the skills to meet the challenges of tomorrow. However, there is a lack of students graduating into the workforce, especially in science, technology, engineering and math (STEM) fields.

According to the U.S. Bureau of Labor Statistics, thousands of STEM jobs are vacant across the U.S., with a noticeable gap in representation from women, minorities and those from underserved communities. Meanwhile, STEM-related careers are expected to grow by 10.8% over the next 10 years. A recent study by the National Institute for Early Education Research showed early exposure to STEM skills is an enormously impactful indicator for future success in these disciplines. Yet, too many students throughout ComEd's service territory (and across the U.S., in general) were not getting this level of educational opportunity and career training. Therefore, the utility stepped up by creating STEM education programs to help develop the engineers of the future.

Mentoring Students

The U.S. Bureau of Labor Statistics reports only 24% of those in STEM careers are women, 7% are Hispanic and 9% are African American. ComEd has developed STEM programs to lessen these gaps by targeting communities in its service territory that are most in need of supplemental STEM education but often overlooked.

Mentorship is the foundation of ComEd's STEM education strategy, and some of the engineers who are mentors come from the same communities as the students who continue to be overlooked. Those engineers can bridge the gap between skill and application in a relatable way. The utility engineers who have built and maintained the grid are the exact people who should be teaching how to transform it.

The impact of these programs is not just the lessons students learn; it is being able to visualize what a professional engineer looks like and does. The connections students form with these engineers help them to identify and navigate the right professional opportunities in their career.

The curricula of ComEd's STEM education programs emphasize technical skills along with teamwork, leadership, communication and presentation skills. The engineers of the future who participate in these programs are being primed to bridge the gap between technological advancement and effective communication. They do not just know how to execute and solve problems; they can explain what they are developing and why, with the ability to lead others to do the same. Teaching these concepts and applications to the next generation also enables today's utility engineers to refine and practice their own communication skills.

Create-A-Spark

In 2019, ComEd's HFS Chicago Scholars' Create-A-Spark program expanded to include 100 total freshmen and sophomore high school students engaging in a presentation of ideas and subsequent competition. Winning criteria for the student prototypes in the competition included the potential to deliver community benefits related to health, safety, sustainability, connectedness, mobility, efficiency and education.

Students who participate in the Create-A-Spark program come from economically disadvantaged Chicago, Illinois, U.S., families and excel academically. HFS reports that more than 90% of these scholars make the honor roll at top Chicago high schools.

In 2019, freshman team "BACK" was awarded US$2000 for an innovative technology concept called Smart Pathways. Smart Pathways was developed to light pathways in an energy-efficient way by using motion sensors and light-dimming capabilities. The Smart Pathways prototype also included safety features such as movement tracking through its light sensors.

This concept reflected a project ComEd smart grid engineers developed as part of the utility's Community of the Future initiative, the ARIS off-grid lighting project. In 2019, ComEd's team developed and deployed seven solar-, wind- and

Mentor leads ComEd STEM program students in project research.

ComEd engineer mentors a STEM program student through project development.

battery-powered lighting units in the Bronzeville neighborhood of Chicago. Seeing ComEd engineers influencing students in real and tangible situations elicits excitement for what these students might do in the future.

Power Challenge

ComEd's inaugural Power Challenge program for sophomore, junior and senior high school students, cohosted by the IEEE Power & Energy Society (IEEE PES), is engaging more than 125 scholars from across the utility's territory to develop energy-related projects for a competition and poster presentation at the IEEE PES T&D Conference and Exposition in October 2020 in Chicago.

This opportunity involves research-intensive innovation for students interested in developing skills in the areas of distribution, transmission, generation and renewable energy. To kick off the initiative, ComEd utility engineers gave presentations to the students on each topic and provided guidance throughout the project selection. More than 50 engineers are mentoring student teams directly throughout the life span of the projects, offering students a chance to develop STEM skills by solving real-world problems alongside professionals in the field.

Students recently submitted abstract proposals to their mentors and are generating a range of projects directly applicable today in electric utility operations. One group is developing a hydroelectric power pump powered by solar energy. Another group, interested in the dangers to wildlife caused by electrocution, is researching improved power distribution methods specifically to avoid harm to wild animals. A more experimentally focused group proposed 3-D printing an electric pole model to test pole tilt and crossarm sensors with the goal of improving pole safety and maintenance.

Mercy Home

ComEd also instituted two summer through fall programs in 2019 with the Mercy Home for Boys and Girls, a nonprofit organization in Chicago that offers safety, residency and education to children in need.

"Our mentors and coaches have the power to inspire us in profound ways, sharing stories and tools that are unique yet relatable. Mentorship creates enriched environments, and the ability to engage mentally and emotionally with students who have differing perspectives is a blessing. I come to work every day to help power lives, and the opportunity to share the art of connecting STEM to practical applications is tremendously gratifying", said ComEd engineer Sainab "Taiwo" Ninalowo.

Students at the Mercy Home for Girls learned to work with

circuit boards and build projects, such as a working FM/AM radio. They also got an opportunity to hear from female ComEd engineers about their life stories, which empowered the girls to share their own life experiences. Similarly, the Mercy Home for Boys students were introduced to ComEd engineers and professionals who shared their life experiences and academic paths to model the value of rising to meet challenges. They also had an opportunity to see ComEd linemen and electricians in action.

ComEd Engineer Sainab "Taiwo" Ninalowo tells Mercy Home students her life story.

Future Engineers

These ComEd programs serve as an opportunity to spark an energy and sustainability mindset in students, encouraging the younger generations to contribute to their future by solving real-world challenges. A significant and ever-present theme throughout each of the programs is ensuring students understand the effects of climate change and are well-versed in strategies and habits they can use now to decrease their carbon footprint and keep climate change issues in mind when developing engineering projects.

A STEM-prepared population well-versed in climate change issues will support maintaining and developing innovations to solve current and future energy issues. This valuable exposure works to spark STEM interest in young people and open them up to career possibilities they might not have considered otherwise. What is more, as students learn to meet challenges that arise in their own lives, they will be better prepared to meet external challenges, solving problems on a larger scale.

For students who participate in ComEd's STEM education programs, mentorship is a key component. The engineers teach STEM skills, expose students to the latest technology and help them to cultivate a problem-solving mindset. It is imperative not just to solve today's problems but also to mobilize a plan to overcome the energy problems of the future. The best way to plan for the future is to invest in the children who will build it. ComEd's team believes this and will continue helping to develop the engineers of the future. TDW

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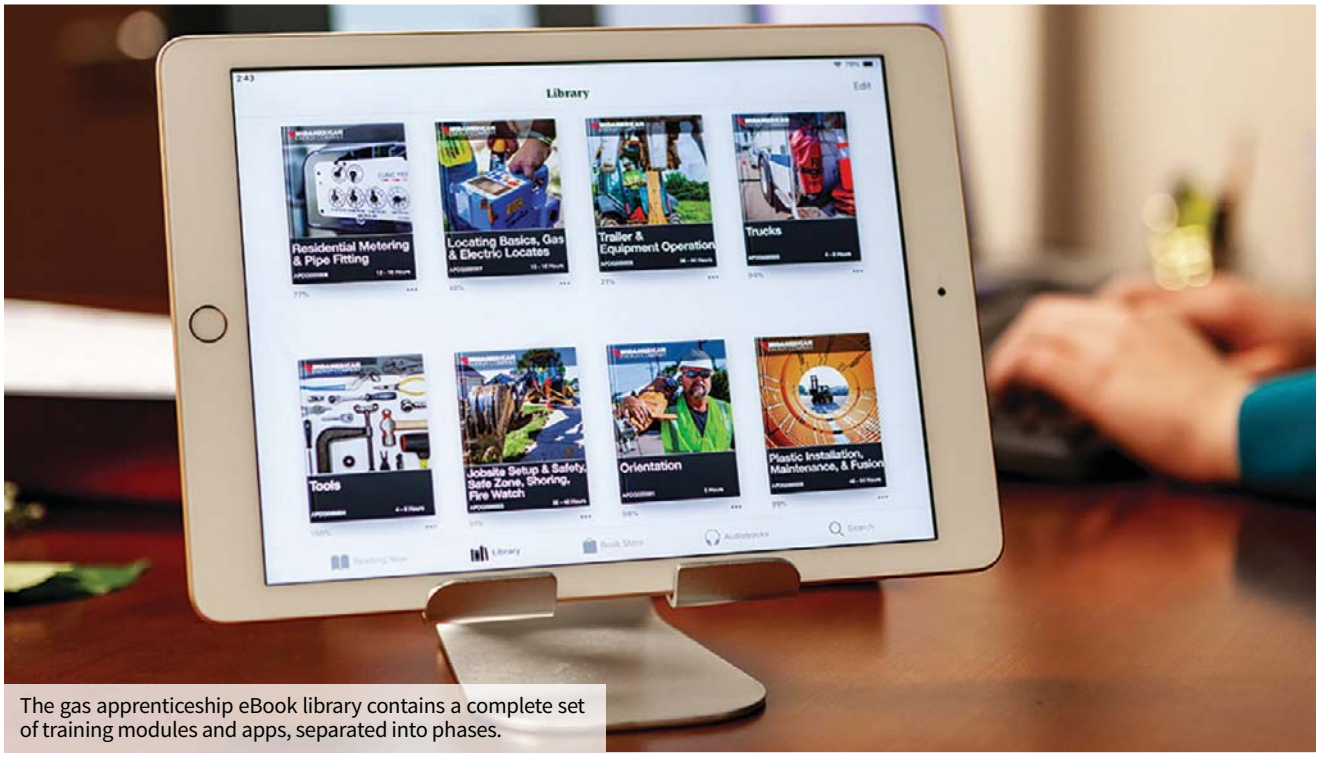


The gas apprenticeship eBook library contains a complete set of training modules and apps, separated into phases.

Utility Dives Into AR to Train Apprentices

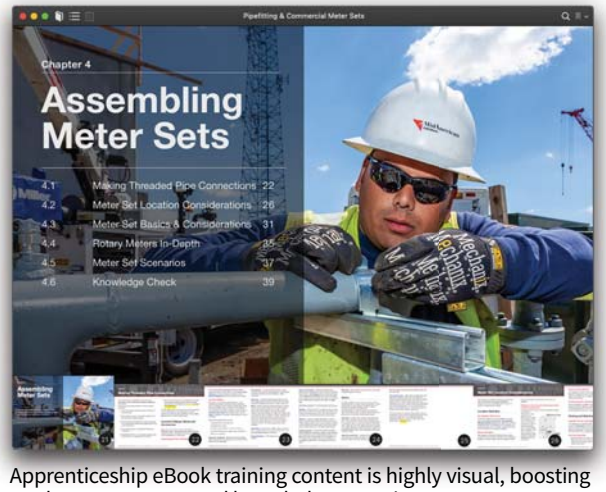
MidAmerican uses a blend of augmented reality and eBooks to develop a digital curriculum for its apprenticeship programs.

By **Mike Hoff**, MidAmerican Energy Co.

Like many other utilities, MidAmerican Energy Company trained its apprentices in a traditional classroom setting with large binders of information and how-to videos on VHS. After reviewing the materials in the classroom, apprentices would practice hands-on activities with trainers providing guidance and instruction.

Today, the utility has partnered with Index AR Solutions to create a digital training curriculum for its apprentices. With augmented reality (AR), MidAmerican has created step-by-step augmentations walking apprentices through the hands-on activities and providing tips and tools to get the job done safely and correctly the first time.

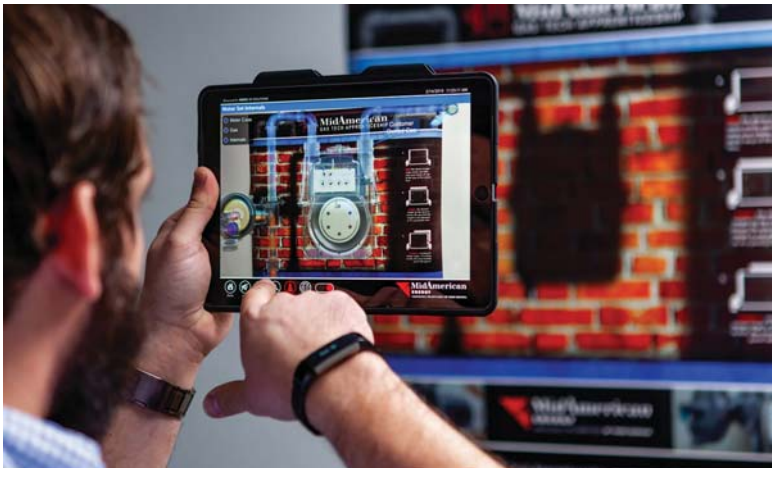
MidAmerican's journey into AR training began back in 2014. The utility entered into an agreement with its labor unions to optimize its resources by combining its two primary



Apprenticeship eBook training content is highly visual, boosting reader engagement and knowledge retention.

Videographer prepares to film worker demonstrating a pipe fitting fusion procedure for video to be used in apprenticeship training eBook.

Worker demonstrates the proper pipe fusion procedure for training video to be used in apprenticeship training eBook.



Worker uses a tablet-based app to visualize gas meter internals.

A developer works on an app that helps teach apprentices how to quickly and easily read gas meters.

time-based gas apprenticeship programs into one competency-based hybrid program — gas technician.

As the apprentices were required to retain more information over a shorter period of time, the need for innovative, engaging training was evident from the start of the gas tech-nician program. MidAmerican came across the AR work from Index AR Solutions and was drawn to it for training and field applications.

The utility realized that a gap remained with the written training materials, and it decided to pair the AR with eBooks. By pairing them together, the utility has put a complete curriculum into the palm of every apprentice's hand via a tablet.

Creating Videos

AR provides step-by-step guides for apprentices to complete everyday tasks such as building a residential meter set. The augmentations walk the apprentice through what personal protective equipment (PPE) and tools are needed for each step and overlays critical information on to the area they are working.

MidAmerican has also used AR to show how elements of the system, such as a regulator or meter work. An apprentice's understanding of how equipment works in the field accelerates their ability to diagnose system issues in real time.

eBooks have also become a repository of the knowledge of the utility's workforce. The written material in the eBooks is enhanced with short video clips of the employees showing how to complete a task or walking through how to set up a work zone. Other videos include employees talking about their experiences in the field. These videos, which capture the knowledge of the aging workforce, can be shared with every apprentice.

By using short, YouTube-style videos, the utility is able to increase knowledge retention and align the instructional approach with how many indi-

viduals learn do-it-yourself type skills. MidAmerican has also been able to inject safety warnings and human performance tools into the AR applications and eBooks to keep safety top of mind. Many of the eBook videos focus on safety tools and techniques.

A gas trainer walks new apprentices through the eBook training materials delivered on the tablet.

Launching a Program on the Electric Side

Now that MidAmerican has rolled out the AR training program for the gas technician apprenticeship, the utility is now focusing on introducing it to the electric apprentices. One of the major lessons learned from the gas technician apprenticeship program was to assign ownership to a dedicated project leader and involve everyone — especially the represented workforce — in the process.

The utility did not start this project with a list of AR applications. Instead, the applications MidAmerican has developed have come organically from what is important and critical to its represented workforce. For example, employees are lining up to tell their stories and contribute to the eBooks, which reflects the represented workforce's commitment to their craft, and ultimately, their customers. The company is taking this same approach when developing training tools on the electric side.

All of MidAmerican's existing apprenticeship programs have written materials and structured curriculum, which establish the eBook framework and written content. Once the team defines the framework, they collaborate with the represented workforce to determine what photos, animations and videos are needed to enhance the eBooks. The utility then travels throughout the service territory to create the digital content.

The company is taking the same approach with AR applications. Once MidAmerican has established the eBook framework, the team comes together for an idea session on what tasks and concepts would be best reflected using the technology. The majority of the ideas come from MidAmerican's represented workforce.

Accessing Training Anytime and Anywhere

MidAmerican kicked off the development of AR and eBooks for its electric meter technician last year with the project on track to be completed in 2021. Once the company has completed its gas technician apprenticeship and gas welding apprentices, it will begin development of the program for its primary electric apprenticeship — the line mechanic. The development should begin in late 2020 or early 2021.

Each apprentice is issued a company-supplied iPad on their first day of work loaded with all the training materials, as well as standards manuals and safety rule book. The tablet, the training materials and their notes all stay with the apprentices even after they complete their training.

Having the training materials on tablets provides apprentices with broader accessibility of the materials. The next step for when apprentices are in the field is to connect them back to trainers or subject matter experts when they need additional support. MidAmerican is researching ways to accomplish this using existing video-calling technology, such as FaceTime, so the apprentice can contact any trainer or subject matter expert remotely, show them the challenge they are facing and work with them to come up with a solution in real-time.

The company is committed to providing all employees, both represented and non-represented, with eBooks and, if applicable AR training. The company has also begun developing eBooks for its non-represented employees focusing the initial effort on engineering positions. Many of those eBooks will leverage the materials already developed for the gas technician apprentice.

Looking to the Future

MidAmerican is now exploring wearable technology such as creating a hands-free tool for when apprentices are working on equipment both in training and in the field.

The AR applications and eBooks are reinvigorating the company's apprenticeship programs, the apprentices and employees. Using the collaborative development approach, MidAmerican has gained overwhelming support and engagement from its represented workforce.

The fit into the programs has been seamless, and the adoption of the technology has been simple as most employees use similar technology on their smartphones. The results and engagement from the employees reflects in the commitment to further develop additional apprenticeships and non-represented training programs using these technologies. TDW

Mike Hoff is the director of business optimization and innovation at MidAmerican Energy Co.

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Grid Monitoring

Utilities today are under pressure to reduce operating losses, extend the life of distribution assets and components, defer capital investments and ultimately ensure that they provide good power quality to their customers. Visit Aclara, a part of Hubbell Utility Solutions, at IEEE PES in October and discover how integrated advanced metering infrastructure (AMI) and distribution automation (DA) solutions help utilities optimize their network operations and best position themselves for the evolving demands of the electric utility industry.

One of these solutions, the Aclara Grid Monitoring platform, provides the situational awareness utilities need to quickly identify and resolve problems while increasing service reliability. Aclara's Grid Monitoring platform uses smart grid sensors to detect faults with real-time information and continuously monitor power quality across all three phases of their medium voltage distribution network. With this actionable data, utilities can boost the reliability, efficiency and power quality across their distribution system with enhanced situational awareness to:

- Detect overload and imbalance conditions.
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- Improve power quality and customer satisfaction.
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LAE | www.lae-srl.com

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The Load-Trainer II Transformer Simulator is a portable three-phase trainer. The unique tactile interface offers an immersive learning environment for all levels of line-workers and utility personnel. The unit includes color coded patch cords and a 7-in. interactive touch screen to combine a physical wiring environment with a computer controlled simulation. Users apply jumpers between source lines, transformers and a secondary system. When the 'TEST' button is pressed the simulator displays phase-to-phase voltages, phase-to-neutral voltages, phase angles, load and other key information based on the users wiring in real-time. Key principles and concepts of electrical distribution systems can be demonstrated: Wye, Delta, Polarity, Phase Rotation and Phase Angles. Trainers can even introduce faults on both the primary and secondary, modify phase orientation, explore multiple secondary voltages and different transformer settings. It simulates back-feeding and reduced capacity services so users learn and practice real-world troubleshooting. The Load-Trainer II Transformer Simulator is 27.5 in. wide by 19 in. tall by 3.5 in. deep and weighs just 16 lbs. It is constructed on a rugged polymer frame and includes built in legs that fold for easy transport. It is powered by standard 120 V AC and includes a cordless mouse and HDMI output for connecting a monitor or projector. The soft case includes padded corners and a pouch for accessories. The hard case includes heavy duty foam, storage area and a spring-loaded handle.

Utility Solutions, Inc. | www.utilitysolutionsinc.com

Substation and Insulator Coating

PPC Insulators has been offering RTV Silicone coated insulators from its factories since 1993. PPC can now perform substation coating services as well as local insulator coating from stock in the United States and Canada to best serve its customers. Its in-depth knowledge of porcelain insulators allows the company to partner with utilities to increase the longevity of their insulators in polluted environments. The company is offering Si-Coat 570 RTV Silicone coating. The Si-Coat 570 is a proven RTV Silicone material that has been used globally with more than 700,000 insulators coated since 1990. PPC offers a range of services to extend the life of utilities' existing assets.

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Leather Protector Gloves

Electric workers now hold all of the protective power in their hands with the arrival of the new Saf-T-Gard Voltgard V-GRIPS Leather Protector Gloves. Available in both low-voltage and high-voltage styles, these gloves are manufactured using a proprietary grip-enhancing coating that covers the entire work surface of the gloves (palm, index finger and thumb) to deliver an unsurpassed grip that won't slip or affect the ergonomics of the gloves and provides dexterity and flexibility, especially when handling small parts. Crafted by leather glove specialists from a durable grain goatskin leather, which protects against cuts, abrasions and punctures and will not absorb dirt, oil, grit, grime or moisture, all styles are dual-sized to fit rubber insulating gloves in whole and half sizes and feature a gunn cut pattern and an adjustable leather strap and metallic buckle to comfortably secure the gloves to the workers' hands. The low-voltage styles fit properly over straight cuff industry-standard rubber insulating gloves and have an arc rating ASTM F-2675 of 38 ca/cm2. The high-voltage styles fit properly over both straight and bell cuff industry-standard rubber insulating gloves and have an arc rating ASTM F-2675 of 28 cal/cm2 making them suitable for use by utility workers, power and communication linemen, electrical contractors, plant and facility maintenance technicians and electrical field service technicians.

Saf-T-Gard International, Inc. | www.saftgard.com

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Mobile DC Power System

Standby Power Systems Consultant, Inc's Mobile DC Power System is a fully customized and furnished portable backup power unit designed specifically for electric utility and telecommunication applications. These trailers provide accessible and fully portable emergency or temporary DC power for critical facilities. Designed, engineered and built by SPSC, each unit is customized to meet the unique specifications and system requirements of the customer.

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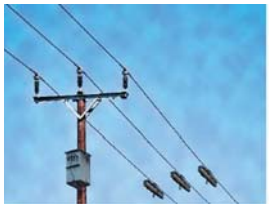
Condux Tesmec's PM1450 hydraulic puller is suitable for a wide range of underground pulling applications including power transmission and distribution cable installation, telecom and fiber. With more than 10 tons (100 kN) of pulling force, the PM1450 features a new digital interface with a 7-in. color display and integrated pull and speed recorder. The unit is available in a DOT-Certified tandem axle trailer configuration, as well as a track-mounted model. The integrated track mount provides operators the ability to maneuver the unit in tight working conditions and easily position the puller for optimum pulling performance. Further, the tracks create less ground disturbance and allow the unit to work in wet, sandy or muddy soils.

Condux Tesmec | www.conduxtesmec.com

Overhead Line Monitoring System



OverLine, CNIguard's Overhead Line Monitoring System (OHLMS) monitors the integrity of overhead conductors and poles used to distribute electricity. Scalable across vast distances, the OHLMS reduces exposure of both public and operators to danger, while improving standards of distribution performance with a faster response to attend site. OverLine will alert line sag beyond the safe limit, pole tilt beyond acceptable limits, line detachment, deflection of line due to contact by machinery , or deflection of the line due to contact with trees or branches.

CNIguard | www.cniguard.com

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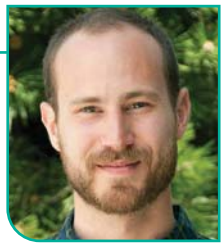
Learning from Aloha



By **Jason Price**, Rocky Mountain Institute

For more than 10 years, Hawaii has been reimagining and implementing a vision for what a new, clean energy paradigm might look like. Hawaii's visionary ambitions for its energy sector can be summarized in two facts:

1. In 2018, Hawaii relied on petroleum to generate over 60% of its electricity.

2. By 2045, Hawaii aims to generate 100% of its electricity from renewables.

In 2015, Hawaii was the first U.S. state to proclaim a 100% renewable energy target. It led the way for more than 100 other jurisdictions to follow suit with similar goals. Now as policymakers and energy stakeholders grapple with implementation of these targets, all eyes remain on Hawaii to demonstrate strategies to achieve 100%.

Rocky Mountain Institute's (RMI's) recent report *Powering Paradise* shines a light on replicable elements of Hawaii's approach to the clean energy transition. The report is a postcard from the future describing Hawaii's experience and offering lessons for those pursuing energy system transformation.

Energy systems are complex, whether on the Hawaiian Islands or on the mainland. No one person or organization can transition the entire system or influence change. It takes a combination of market forces, enabling policy, updated regulations and, importantly, innovation and resolve.

Market

In 2011, an earthquake caused the Fukushima nuclear power disaster and forced Japan to shut down its nuclear fleet. As Japan ramped up production from oil-fired power plants to make up the generation shortfall, oil demand and prices spiked. At the time, Hawaii relied on oil for 80% of its electricity generation, so as oil prices rose, so did retail electricity rates. Monthly utility bills soared, and Hawaii's leadership felt a pressing need to do something.

This prompted state leadership to refocus attention on the goals of a 2008 partnership between Hawaii and the U.S. Department of Energy known as the Hawaii Clean Energy Initiative (HCEI). HCEI envisioned that Hawaii would become an innovation test bed for new technologies and business models to lead the transformation of the energy sector into one based on renewable energy and energy efficiency.

Policy

While market forces catalyzed change, a new policy construct was needed to capture that lightning in a bottle. Through progressive legislative milestones — from the renewable portfolio standard to a more recent zero emissions clean economy target — Hawaii's legislature has created the North Star to orient state efforts toward decarbonization. Thanks to a portfolio of ambitious energy legislation, the goal of energy transition has survived election cycles and changing administrations to remain at the forefront of Hawaii's culture of change.

Regulatory

Policy changes and aspirations can be meaningless without the muscle of regulators to move change through the system. For example, the Hawaii Public Utilities Commission (PUC) is leading a landmark proceeding focused on performance-based regulation (PBR) to align utility business incentives with state policy goals. The PUC is similarly leading a range of other energy reforms to proactively steward the state's energy transition.

A key area of focus for the PUC has been how to fully leverage all the distributed energy resources that residents have adopted, especially rooftop PV. Since electricity rates spiked in 2011, Hawaii residents turned to increasingly cost-competitive solar power. Today, one out of every three single-family homes on Oahu has solar on its rooftop, and distributed solar is the leading source of clean energy in the state.

Utility

Utilities can be innovators or implementors. Hawaii's utilities are both. Hawaii utilities have adapted to the pace of change and embraced the goal of 100% renewable energy. Electric system planning and operations are being redesigned to enable customer choice and manage two-way power flows. An active proceeding on integrated grid planning is working to optimize the beneficial integration of distributed assets and harmonize traditionally separate planning processes for the bulk and distribution systems.

Lessons from Hawaii's Experience

Although Hawaii's story is still being written, three lessons are emerging from the collective efforts of the state's energy community:

1. A willingness to try — Hawaii is constantly pushing boundaries, without always having a clear script for where it will go. Others can learn from Hawaii's missteps, but should also be emboldened to take their own risks, assured that rapid feedback loops will accelerate rather than impede progress.

2. Clear guidance from leadership — From the justification for the 100% renewable energy goal, to the framing for the utility of the future and expectations for stakeholder engagement in regulatory proceedings, Hawaii demonstrates the importance of establishing reasoned, clear, and compelling intentions for the energy transition.

3. Stakeholder engagement — As it stepped into the unknown, Hawaii has consistently crowdsourced invaluable wisdom from local stakeholders, as well as drawn upon national and international experience. Ensuring broad support for its actions has been critical for maintaining momentum and making progress toward goals that benefit everyone. TDW

Jason Price works in RMI's electricity practice, where he focuses on DER deployment and integrated grid planning.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