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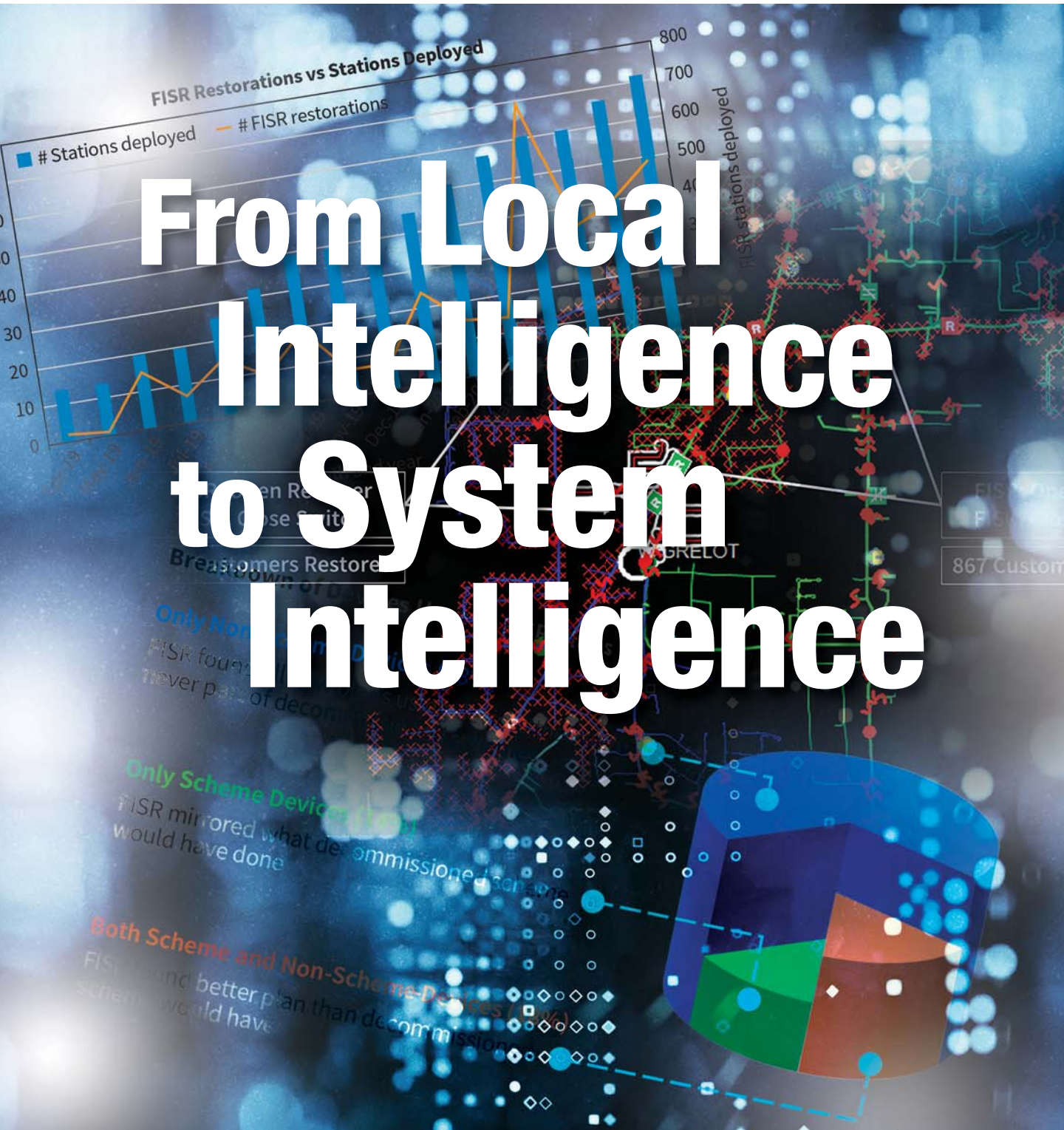

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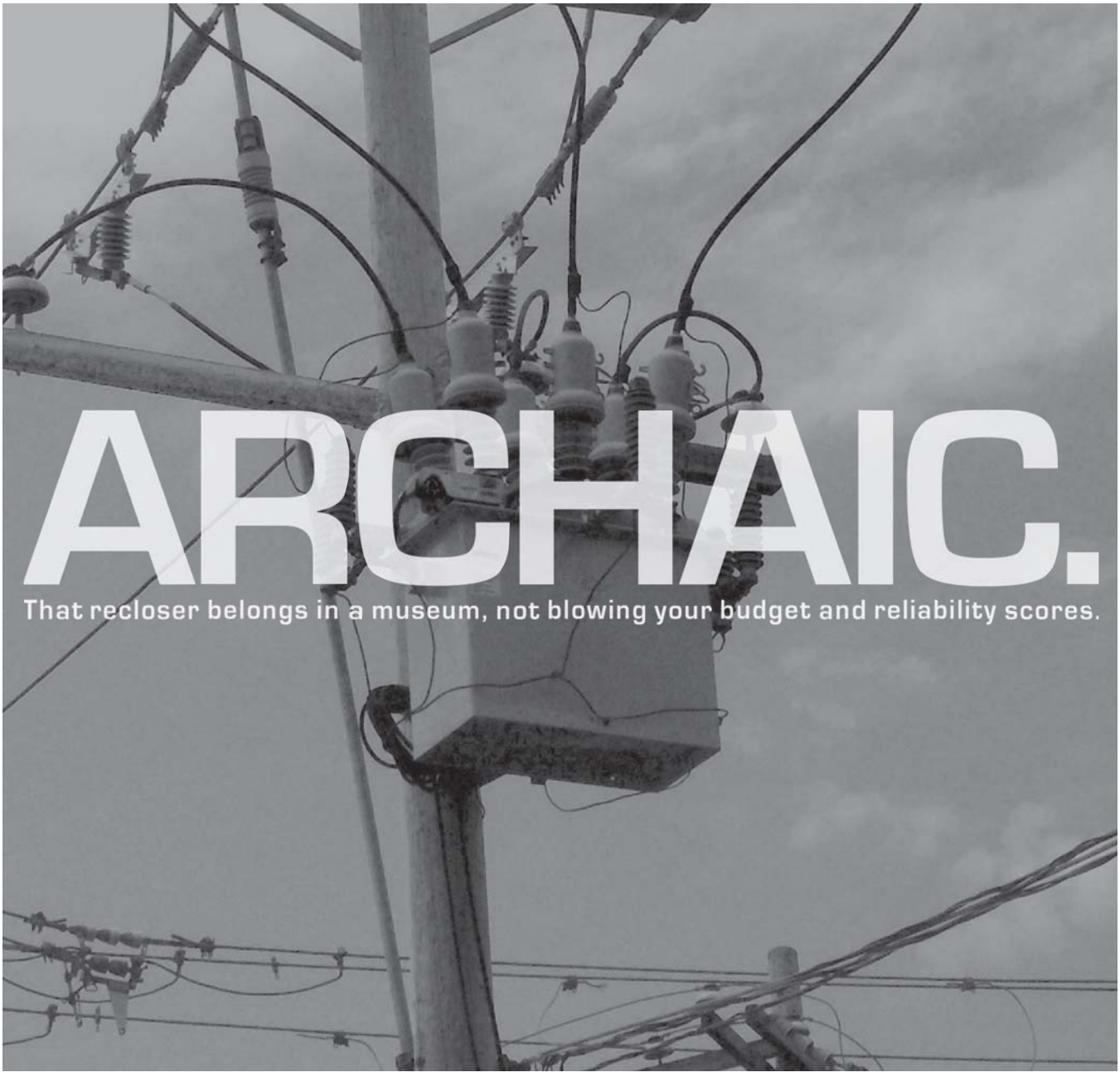

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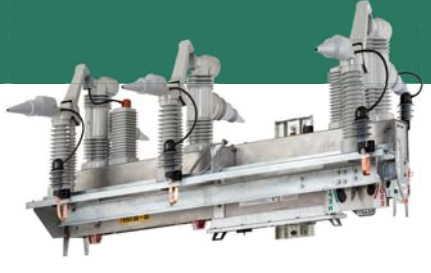

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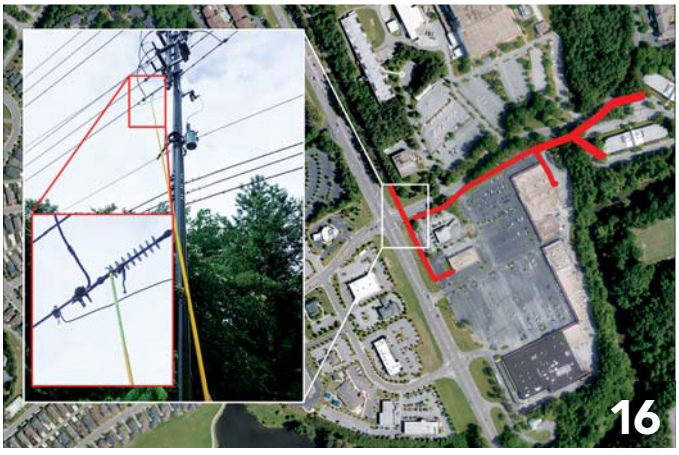

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- Neil Vandermeulen
Division VP

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Strategic Undergrounding

Widespread outages from recent natural disasters- hurricanes, heatwaves, wildfires, wind, and ice storms- have the attention of utilities, regulators, legislators, and customers alike. They want solutions.

Early in my career, I worked for a state PUC and spent many long nights at public hearings related to utility storm response investigations. I fondly remember a customer referring to the area they lived as the "the land of trees." He, along with many other customers, recommended that the utility bury all their facilities. At this point in the hearings, the utilities would generally respond with the astronomical cost to underground all lines. Not much would change and, we would all repeat this same grueling process during the next storm season- widespread outages, high storm restoration costs, outraged customers, and equally enraged politicians. However, this dichotomous approach to undergrounding need not be the case.

Electric utilities can accomplish grid resilience in different ways, but most efforts are focused on either a plan to harden the overhead system or place facilities underground. As previously alluded, from a cost and logistical perspective, it is not always feasible to underground all facilities. However, a potentially cost-effective approach is to select lines to be placed underground based on specific design requirements and perceived societal benefits. As part of the solution, electric utilities have implemented strategic underground programs to help optimize the resilience of their distribution systems.

Strategic undergrounding is a data-driven approach that identifies critical overhead distribution feeders, equipment, and lines as candidates for proactive undergrounding. A strategic undergrounding program helps identify the lines most prone to outages and considers undergrounding to improve grid resilience and the total time of restoration of overhead distribution lines.

Our industry needs to evaluate the lifecycle cost of distribution line assets. Utilities are now getting excellent and current initial price, performance, and O&M data. Utilities like Dominion, Florida Power & Light, Georgia Power, Pepco, and others are starting to analyze the results with this new data.

Pepco's District of Columbia Power Line Undergrounding (DC PLUG) initiative is a US$500 million project jointly funded by Pepco and the District. It focuses on the underground placement of up to 30 of the most vulnerable power distribution lines. In the face of increasingly severe storms, the DC PLUG initiative expects to improve resilience and to improve reliability on selected feeders by an estimated 95%.

San Diego Gas & Electric is also working on expanding the underground electric infrastructure in the town of Julian in San Diego County, California, as part of its ongoing effort to reduce wildfire risk and the impact of Public Safety Power Shutoffs (PSPS) during extreme weather conditions. For SDG&E, the strategic undergrounding of overhead power lines is one element of a multi-pronged approach to reducing wildfire risk.

Dominion Energy has been studying the effectiveness of its undergrounding efforts for well over a decade. In addition to SAIDI-based reliability programs, the utility also focuses on Total Length of Restoration (TLR) to improve overall reliability. Dominion's data analysis indicated the need to focus on distribution tap lines to improve TLR. For Dominion, tap lines made up 50% of its total overhead distribution line mileage, and 60% percent of its tap line outages occurred on 20% of the tap line mileage. They then understood that the target was to concentrate on undergrounding that 20%, where possible.

Karen Kinslow, Director of Grid Resiliency at Dominion Energy, told T&D World, "The first thing everyone thinks about is the cost of undergrounding. And while upfront costs are significantly more expensive, we began by strategically targeting the most outage-prone lines. Our analysis showed we could eliminate up to 50% of recovery time after a severe weather event just by putting 20% of our tap lines underground. We're only about a third of the way done, but already we're seeing time off our major events. Other utilities have reached out and asked about our experience with undergrounding. They may tackle it a different way, but my advice is to analyze the data and focus on areas with the highest risk."

Another critical point Karen emphasizes is that undergrounding just a portion of Dominion's overhead lines provides value to all customers, not only those directly placed underground because it reduces work when the utility responds to a severe weather event. Dominion Energy's 10-year Strategic Underground Program® has reduced the repair or recovery time after large storm events by 40-50%. Our next issue of T&D World, in December, will also feature an in-depth case study about Dominion's strategic undergrounding program.

Additionally, T&D World also recently hosted a webinar about Strategic Undergrounding on October 13th, where Dominion Energy shared seven years of "lessons learned" and project success with strategic undergrounding. Karen also discussed customer satisfaction and communication, project selection, implementation, and measuring results. You can register for this free webinar at *https://www.tdworld.com/resources/webinars/webinar/21140194/webinar-strategic-undergrounding-dominions-lessons-learned*

Strategic undergrounding is an excellent opportunity for utilities to build a more reliable and resilient system, improve the aesthetics of communities, and add shareholder value as we move into 2021 and beyond.

Until next time, stay safe! TDW

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Risk-Based Business Continuity Plans

By **David Shadle**, Senior Editor

Three quarters of 2020 is in the books and, unfortunately, electric utilities through no fault of their own, are worse for the wear. A derecho tore up the Midwest; wildfires struck the usual Western states; tropical storm Isaias walloped the Northeast; Hurricanes Laura and Sally devastated parts of the South; and disasters caused mayhem in additional pockets around the country. Power companies are in business to provide safe, reliable, and affordable electric service to their customers 24/7. Can we do more to improve the reliability and resiliency of our operations?

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A growing number of electrics are turning to risk-based business continuity plans to improve preparedness. Risk-based planning is not for the faint of heart. Your eyes will roll into the back of your head quicker than you can say chi-squared if you focus on abstract issues. It's easy to run down rabbit holes worrying about what is an inherent risk and what is a residual risk. However, the overarching goal of risk-based planning, which is to prioritize where to focus limited resources to achieve the greatest level of resilience or recoverability, is more critical today than ever before.

Freebase describes business continuity as a broadly defined set of planning and preparatory activities intended to ensure that an entity's critical business functions will either continue to operate during serious events that might otherwise have interrupted them, or will quickly regain operational status. Business continuity strategies generally address:

1. Resilience-design or operation to ensure critical business functions are not significantly affected by disruptions.

2. Recovery-preparations for restoring functions that are damaged in an event.

3. Contingency-measures to regain critical functions if primary plans are not successful.

Putting risk analysis and business continuity planning together yields the modern version of emergency planning on steroids. For those folks who avoid statistics, take heart, because most of the heavy lifting for risk assessments today can be performed by powerful computer modeling. In fact, advanced analytics can be employed to predict how weather events, natural disasters, and myriad other types of events impact outage risks. With such knowledge, organizations can optimize capital and operational expenditures to maximize reliability and resiliency. Further, better insights for recovery and emergency response planning are possible.

There are many sources for guidance regarding business continuity planning. Two examples cited by Randy Heisler with Life Cycle Engineering during a recent presentation are NFPA 1600 and ISO 22301. These standards cover plan creation, implementation and maintenance for continuity, emergency, and crisis management. Documentation, training materials, exhibits, SOPs, forms, and audit checklists are available for both the NFPA and ISO standards.

Comprehensive business continuity plans (BCP) should address all risks faced by an organization. After this year, we realize we must plan for pandemics and abnormal environmental threats such as smoke-contaminated air. Also, cyber and physical infrastructure threat protection are increasingly critical to minimizing disruption to structures, operational technology, data, business functions such as call centers and essential work force communications. The list of business continuity threats appears to be growing, but near the top for many utilities for a long time have been weather and vegetation.

Together, weather and vegetation are leading contributors to utility outages. One company has combined near-real-time data, machine learning and artificial intelligence to help utilities optimize vegetation maintenance programs and utilize outage prediction solutions to better prepare for weather-related outages. IBM offers cloud-based services which gather the extensive quantities of granular satellite imagery and weather data needed to perform these tasks; something few utilities have the resources and expertise to do on their own.

Bob Berglund with IBM's The Weather Company explained during a recent *T&D World* webinar how data from satellite imagery and other sources can be used to perform spectral analyses for an entire utility service territory to provide near real-time vegetation outage risk assessments. Combined with weather forecasts and utility asset as well as historical outage information, The Weather Company can provide extremely specific outage risk predictions from seven days to 0 hours before a weather event. The company's modeling capabilities even extend to predicting where flooding may be a problem. Collectively, IBM's tools can aid with all three aspects of business continuity planning: resilience, recovery, and contingency.

Many prognosticators believe we will see increased frequency and severity of storms, wind, and drought. We know there are other risks on the rise as well. Thankfully, there are an increasing number of resources, including valuable planning tools, increasingly assessable data, machine learning and AI to help us prepare. As Randy Heisler recently told an audience, even when small risks align, bad things can happen. Unfortunately, we cannot eliminate all disruptive events, but we can prepare for them and mitigate their impact on our businesses with solid risk-based continuity plans. TDW

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* Based on "OVERHEAD LINES UNDER EXTREME HEAT RESULTING" by Jean-Marie GEORGE (Scientific Director) & Sandrine PRAT (PhD Research Manager) - T&D World library - WILDFIRE RISK MITIGATION FOR ELECTRIC UTILITIES.

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Upgrade Or Not

By **Gene Wolf**, Technical Writer

Here we are in November once more. I love this month with its cooler temperatures, which is a plus for desert dwellers. Mostly I'm excited that this is the month of tech-toy madness. It used to be called Black Friday with stories slashing their prices to get shoppers in a feeding frenzy. E-commerce changed all that, but the brick and mortar stores have gotten into the fray. Now it seems that the entire month is set aside for price cutting. The big decision is when to jump into the water and grab the desired tech-toy.

My smartphone is over two years old, and there have been several generations of technological upgrades since I bought it. To make matters worse it is a 4G phone, and now all of the carriers are shouting about their latest and greatest 5G network technology. According to the carriers it is the greatest advancement in communications that I can't live without.

5G mast. Photo credit: Ericsson.

The hype says 5G is 10 times faster than what I have and with upgrades could eventually be 100 times faster. This 5G technology offers some great benefits. It will have more bandwidth, which means it can handle more connected devices. No more spotty service in crowded areas. Faster connections to the server (i.e., no wait times). It can even connect to cloud platforms faster and easier, but there is a catch.

Hardware Intensive

This next generation cell technology uses millimeter-wave operating bands, wider channel bandwidths, and active antenna arrays to make it work. That is a lot of totally new infrastructure. There are also other tasks needing to be addressed before the carriers can deliver the kind of coverage customers expect and that is going to take time. Until it happens, there isn't a great deal of difference between the 4G/LTE and the new 5G for most of us.

As one 5G guru put it, the 5G looks good on paper, but it reality doesn't match the hype yet. In other words, there isn't the installed infrastructure to support the new 5G smartphones. All the reviews say the fast 5G service depends on you living or working near a 5G hotspot. Otherwise, these speedy devices operate in the 4G and LTE ranges, and will stay that way until the carriers expand.

That got me thinking about our electric grid. I have read a lot about the smart grid's dependence on communications systems. Recently I have seen many references to the 5G technology being incorporated into the latest grid platforms. After some web searching and reading a great many papers and reports, I had a headache, but I did get a better understanding of the issues.

What About the Smart Grid

The grid needs state-of-the-art, two way communications because that is the way data and electricity flows. You might say the grid communication devices need sophisticated communication systems that can handle whatever is thrown at them. There isn't a one-size-fits-all solution when it comes to picking the communications solution.

My area of engineering expertise is power electronics, but I always had access to communications specialists for the heavy-lifting. With that in mind I had a chat with a colleague, Michael Dulaney. Michael is the head of the Global Performance Center, Wireless, at Hitachi ABB Power Grids.

Without getting into a lot of theory and details, Michael explained there are a lot of different communication architectures in use, and it is not unusual to find several different types of communication systems being used by different parts of the enterprise. He said, "These schemes can vary greatly such as public and/or private cell networks, broadband mesh networks, and others. Silo systems are costly and a problem when it comes to new technologies."

He pointed out, "Communication systems have to be able to adapt to what the future brings. A system that is designed to be expandable and is modular is one of the best choices. That type of system minimizes the trauma and expense of upgrading. It's better not to be frozen until 5G comes along, and systems that have optionality and flexibility can be adapted better for the future."

All of this discussion has given me a different perspective of our smarter grid's communication systems. Dealing with legacy equipment in this changing technological world is challenging, but sitting on the sidelines isn't a choice. The smarter grid needs cutting-edge technology, and systems designed for technological flexibility are better than taking a wait-and-see approach. TDW

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Midwest Energy Companies Pledge To Build Nation's Largest Interstate Electric Vehicle Charging Network

▶▶The electric vehicle (EV) isn't as popular as the gasoline power automobile, but that is changing. EV owners will soon be taking road trips across the Midwest with increased confidence. That's because six regional energy companies have committed to a first-of-its-kind Memorandum of Cooperation, committing to work together to build a vast network of Midwest EV charging stations by the end of 2022.

Six energy companies have pledged to support this project, including Ameren Illinois, Ameren Missouri, Consumers Energy, DTE Energy, Evergy and Oklahoma Gas and Electric.

"Ameren is committed to delivering a cleaner energy future for our customers, our communities and our country," said Warner Baxter, chairman, president, and CEO of Ameren Corporation. "We are excited about this opportunity to work with other energy companies and lead in the clean electrification movement that will deliver long-term value to our customers and our nation."

According to the Edison Electric Institute (EEI), there are more than 1.5 million electric vehicles on U.S. roads today. By 2030, that number is expected to grow to 18.7 million. To support EVs by that time, 9.6 million public charging stations will be needed and only about 100,000 are available today.

"Ameren Illinois has been implementing a modernization plan to prepare the grid for the increased customer demand for cleaner energy, including electric vehicles," said Richard Mark, chairman and president, Ameren Illinois. "Our focus in joining this multi-state coalition is to develop a charging infrastructure that will help reduce 'range anxiety' and lead to broader adoption of electric vehicles."

Marty Lyons, president of Ameren Missouri, said, "By partnering in the creation of a multi-state electric charging network with energy companies outside of our own footprint, we are able to help our customers safely and economically travel to far-ranging destinations. Detroit to Oklahoma City or St. Louis to Denver, we are supporting our customers, our communities and our country with cleaner driving."

Utility programs supporting the Memorandum of Cooperation are subject to regulatory approvals and aim to have the charging infrastructure in place by the end of 2022. While about 40 models of EVs are on the road today, in two years, the Electric Power Research Institute forecasts that we will see more than 130 models available. With these new stations, customers across the Midwest can have range confidence whenever they travel, while helping take care of the environment.

"Expanding the use of electricity in transportation saves customers money, improves the environment by reducing emissions and enhances quality of life for everyone," said Edison Electric Institute President Tom Kuhn. "By deploying charging infrastructure and accelerating electric transportation, EEI's member companies, including Ameren and the other companies collaborating on this initiative, are working together to build a cleaner and stronger economy for the future."

Hitachi ABB Power Grids Expands Tropos Portfolio With Wireless Strategy For Utility And Industrial Communications

▶▶There are no single communication technologies that are perfect for every operation, but if they have optionality and are flexible, they will meet the operational challenges facing today's utilities. Hitachi ABB Power Grids has introduced its new wireless communication solution with the launch of the Tropos TRO600 portfolio. The new future-proof hybrid wireless architecture integrates cellular, self-healing broadband mesh technologies and partner sub-GHz technologies to enable a growing number of utility and industrial applications.

The system seamlessly integrates 2G, 3G and 4G LTE communication technologies, self-healing broadband mesh and select sub-GHz technologies from its eco-system partners into a single device. The new TRO600 series builds on the Tropos foundation of high availability, proven reliability, IP standards-based security, high throughput, and low latency products. The solutions help to future-proof mission critical operations in utility and industrial environments.

"Expanding applications require our customers to change the way they operate their communication networks. With Hitachi ABB Power Grids' new wireless portfolio, we are introducing a comprehensive hybrid network that addresses unique operating challenges of disparate, purpose-built communication networks," said Massimo Danieli, managing director, Grid Automation business unit, Hitachi ABB Power Grids. "TRO600 is backward compatible for legacy investment protection and is future-proof for many years to come. Edge-compute capability will enable our customers' digital transformation journey to an increasing number of Industrial IoT applications," he added.

The new TRO600 portfolio of wireless products offer the optimal combination of technologies to meet multiple use cases in mining, oil and gas, utilities, and smart cities, and are configured to the customers' specification. The hybrid approach unifies communications to all devices, ensuring fast, secure, and reliable connectivity for each operational need. The solutions provide a combination of interoperable technologies on a single communication network, enabling applications for edge devices, mobile devices, and field networks. This powerful hybrid combination will be fully factory integrated for increased reliability, ease of deployment and reduced total cost of ownership.

Hitachi ABB Power Grids wireless solutions share Supros, a unified network management platform, enabling simpler and more efficient network deployment and operation. The Supros network management system, with powerful visualization tools, manages all the radios in the Tropos network from a single console. TDW

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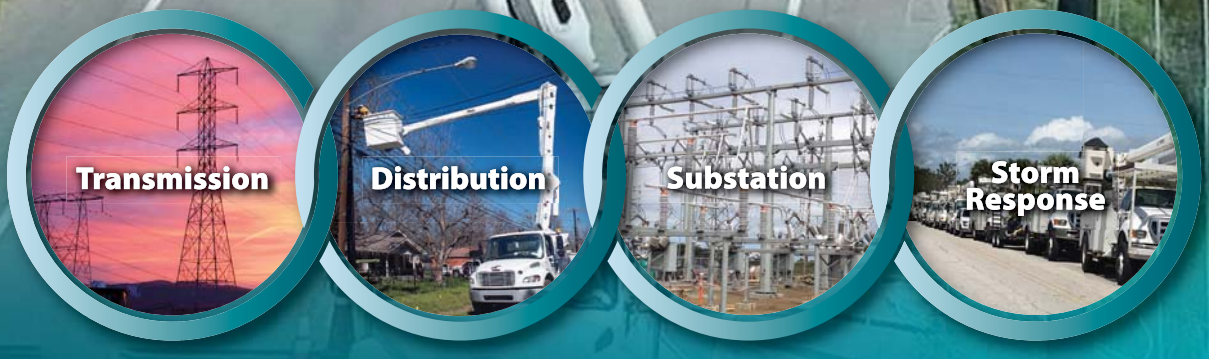

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The Bits And Pieces Are Getting Smarter

We're taking the guesswork out of conditional awareness.

By **Gene Wolf**, Technical Writer

It's been said that digital technologies are breathing life into the electric grid. It's also been said that electricity is breathing life into digital technologies. What makes this paradox interesting is the fact that digital technology and the power delivery system have such a symbiotic relationship. In today's world, neither one can function very well without the other and together they are providing us with tools for the dynamic operation of the power grid.

It's important to understand that the goal is improving the electric power system by making it smarter, and there are several avenues available for this process. One of the more interesting approaches comes from the substation equipment manufacturers. They are taking advantage of some cutting-edge digital technologies to make the substation's bits and pieces smarter building blocks for developing more flexible applications.

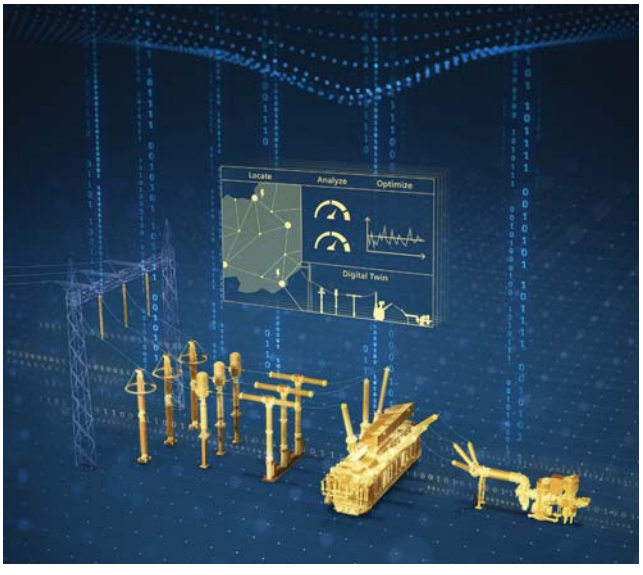
Adding to the challenge is the impact of the 2020 COVID-19 pandemic. Today business as usual has a different definition. Utilities have been required to move personnel offsite and limit their interactions with the public. Demand for electricity has also changed with a shifting from commercial and industrial (C&I) customers to the residential sector. These unanticipated conditions have resulted in a great deal of discussion about the condition of the electric grid, its ability to operate, and its capability to meet the demands of this new normal.

Digital Investments

Halfway through the year, the North American Electric Reliability Corp. (NERC) published its "2020 Summer Reliability Assessment." NERC's report said there were no specific reliability issues identified although they felt there were elevated levels of risk due to the pandemic. While the report eased some tensions, it raised another critical question. Would the pandemic stop the deployment of these smart grid technologies as utilities coped with new challenges?

Around the time NERC's report was released, Newton-Evans Research Company, Inc. published the results of its grid modernization study. The study found that even with the pandemic, 48% of the utilities they surveyed are planning to launch smart grid projects either in 2020 or 2021. Those results say a great deal about the value of modern digital technology to the stakeholders of the power delivery system.

Let's backtrack a little and discuss grid modernization. Modernization is all about putting intelligence into all areas



Digitally connected equipment. Courtesy Siemens

of the grid. Digitalization is the key to making the grid more intelligent. The grid needs intelligent electric devices (IEDs) connected in a network providing real-time data 24/7.

Manufacturers such as Eaton, GE Digital, Hitachi ABB Power Grids, Mitsubishi Electric, S&C Electric Co., Schneider Electric, Siemens Energy, and other suppliers are integrating the IEDs into all points of the grid's substations. It's the mixing of operational technology (OT) and informational technology (IT) and the convergence is producing a cyber-physical world.

Cyber Apps

Grid automation applications and their many offshoots are benefiting from the IED deployment. Smarter apps give utilities a significant operational advantage, including improved COVID-19 response efforts. Smarter products allow utilities to scale back field operations while improving service. One example is the Advanced Distribution Management Systems (ADMS) platform. It has increased connectivity when it's needed most.

These ADMS platforms are taking advantage of the IIoT (Industrial Internet of Things) and cognitive computing - a.k.a. artificial intelligence (AI). The idea is to combine several standalone applications like the outage management system, the network management system, and the demand response system. By combining the functionality of these systems, with

AI, the platform reduces outages and restores service, and improves customer relations without human action.

Another application improving remote operations is the advanced metering infrastructure (AMI) systems. AMI gives utilities the ability to look behind-the-meter (BTM), which also helps with today's health concerns. It reduces the need for utility personnel and the customer to meet. AMI reads meters, turns on service, or turns it off without a rollout. It has also proven invaluable when it comes to distributed energy resources (DER), which commercial and residential customers have embraced.

The customer has become the prosumer with the advent of DER technology, which brought about bi-directional power flows on the grid. DER integrates variable inverter-based resources such as photovoltaics (PVs) and microgrids at the load. Because they have gotten so plentiful, they require the Distributed Energy Management Systems (DERMS) technology to manage this dynamic segment of the grid.

Cyber-Grid

Infusing all of this digital intelligence in the components of the power delivery system's substations has resulted in greater diversity. Substations act as hubs that collect electricity and redistribute it across the electric network. Today they are producing big-data as well.

Manufacturers, utilities, and operators began asking themselves what if these components were also built with interconnectivity in mind? What if the IIoT technology was designed into the apparatus as an integral part and not an add-on to the control systems? What if an interconnected grid was the norm, and utilities could take advantage of real-time management platforms?

A recent discussion with Puneet Singh, vice president digitalization at Siemens Energy Transmission, and Matthias Heinecke, head of product digitalization switching products at Siemens Energy Transmission, shed light on the benefits of the company's connective substation portfolio. By having connectivity built into the individual transmission products, Siemens Energy is bringing in a new level of digitalization.

Singh explained, "Siemens started with a plan of converting the substation into a data hub, providing additional system intelligence. In 2018, we introduced Sensformer, which placed the digitalization where we felt it will do the most good: in our transformers. Today over 500 Sensformers have been delivered and are proving the concept of connective transmission products."

Singh continued by saying, "This was followed in 2019 when Siemens introduced Sensgear, which added digital connectivity to all main substation assets allowing operators to check their status via online applications in near real-time. Siemens' philosophy is that 20% of the transmission equipment should be able to tell 80% of most important events taking place in the substation. This approach is quicker and more efficient than trying to instrument 100% of the station equipment."

As the discussion continued, Heinecke pointed out, "By designing the digital technology as an integral part of the device it puts the intelligent sensors exactly where they are needed. In effect, the technology has the potential to turn the substation into a digital twin, which is basically a digital copy of real asset. With this technology transmission grid operators are enabled to better operate the equipment and act on varying stress levels caused by volatile loads and generation. Having these devices digitalized gives the utility an excellent view of the impacts on the life of the equipment."

Extending Reality

With more and more IIoT capable equipment being deployed on the grid, the digital substation's focus has shifted from the controls to the total facility. These digitalized substations are capable of being part of a virtual network brought about by digital twinning.

With all these smarter bits and pieces multiple substations can form a common network connected through digital twin technology suppling customized services. It is a flexible infrastructure designed for better resilience and boost the grid's efficiency. With the aid of AI, the complicated electrical grid can be easily simplified.

AI takes complex big-data and simplifies it into actionable information, which provides the platform with the ability to improve the operation of the assets. Throw in cloud-based computing services and it improves big-data analytics. These combinations provides a situational awareness to the electric grid's 21st century substation.

As this trend continues, the grid-reliability capabilities of digital substation's systems and platforms increases. These systems reduce the amount of effort required to manage critical grid resources, which can refocus vital human resources to the more efficient operation of the network.

One example of this is GE's approach to the digital substation with the IEC 61850 process bus. The process bus moves data from the smarter equipment into the control room on fiber optic cables, which simplifies the substation's architecture. Gone are the miles of copper control cable replaced by digital directness.

Another smart application comes from Hitachi ABB Power Grids for AI enhanced edge-deployed digital twin technology that operates in real-time. Solar inverters are a good example of this. These devices utilize AI cloud-assisted analytics to provide ancillary services such as voltage and frequency regulation, power factor correction, and reactive power control.

Schneider Electric, Bentley Systems, and Microsoft have formed a partnership to developed what they call a digital twin "living blueprint." This smart application is designed for C&I smart building owner's to use technology to improve energy efficiency.

The power delivery industry has gone digital just like the rest of the world, and technology-enabled substations are one of the key elements of the digital grid. These intelligent substations are moving the grid toward its goal of being self-managed and self-aware. A lot of experts say we need a more flexible and more intelligent grid. These smarter substation components are making the grid super-smart! TDW

From Local Intelligence to System Intelligence

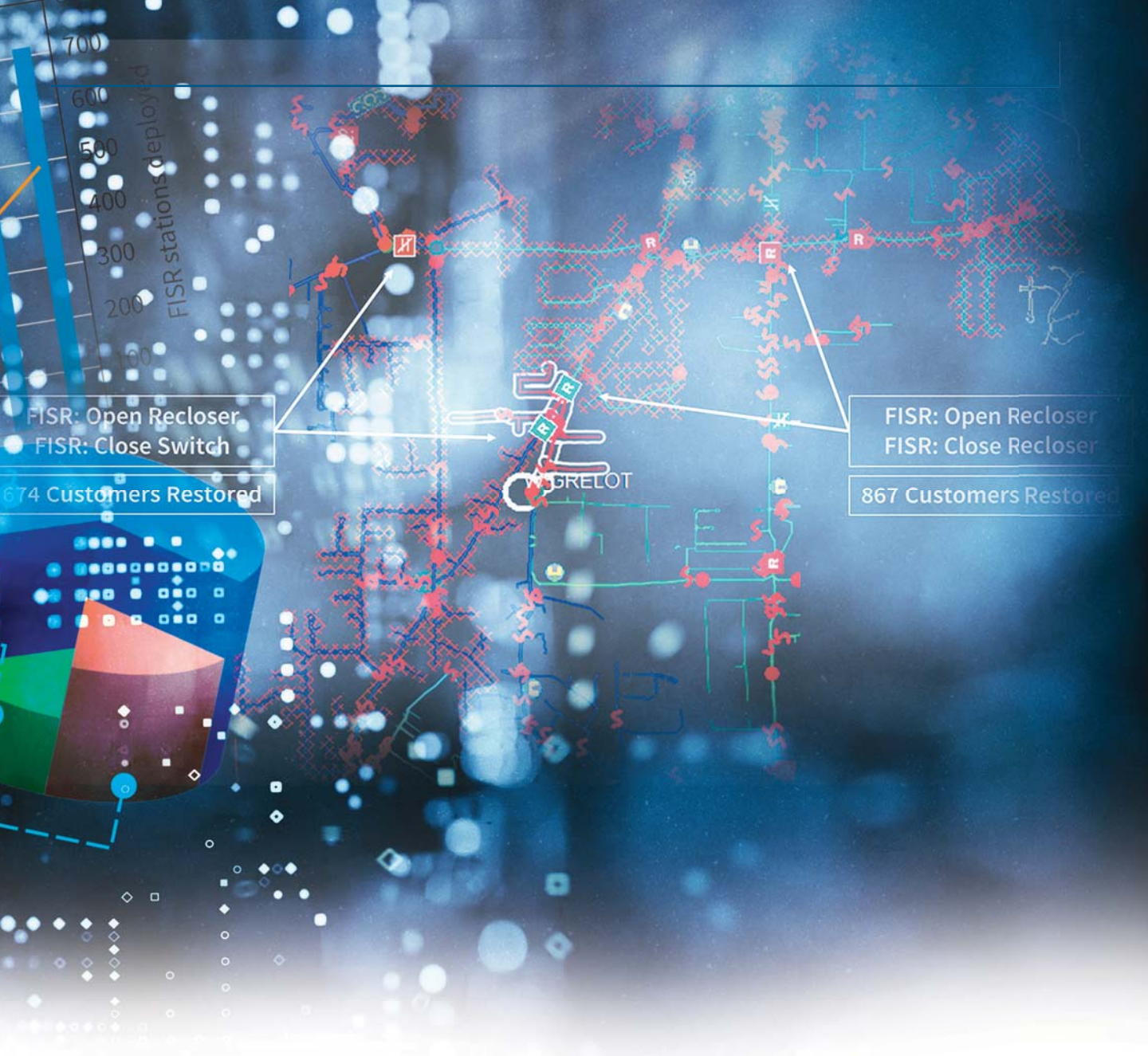
Alabama Power's distribution system advancements minimize outages and restoration times.

By **Matthew Leak**, Alabama Power Co.

Two of the most revolutionary advancements Alabama Power Co. has seen in distribution came with the implementation of both Fault Isolation and Service Restoration (FISR) as well as Fault Location (FL) in its Advanced Distribution Management System (ADMS). These two advanced applications have changed not only the way the utility views automated devices, but also how it uses them. With utilities seeking ways to make the best use of automated devices, using FISR and FL in an integrated ADMS is a powerful way to make a positive impact on their business and their customers.

FISR And FL

FISR is a model-based application that analyzes emergent outages dynamically in the system to develop restoration plans, check them for potential issues using real-time power flow, and implement the switching steps through Supervisory Control and Data Acquisition (SCADA) controls. Although FISR is a form of Fault Location Isolation and Service Restoration



(FLISR), there is one key difference between the two. While FLISR requires the use of FL halos to dictate where to sectionalize lines, FISR relies on SCADA fault targets.

Although Alabama Power's ADMS solution from GE Digital can be configured to run FLISR or FISR, the utility is careful to specify it uses FISR, with FL running separately. FISR can run in several different modes — from closed-loop mode, which automatically uses automated devices to restore customers, to advisory mode, which provides recommended restoration plans using all available switching devices on the system.

Alabama Power is no stranger to local schemes, having deployed many different setups over the years. When compared to these time- and maintenance-intensive traditional schemes, FISR has some attractive qualities.

Because FISR resides in the ADMS itself, no special relay logic is required for field devices. With this bird's-eye view in ADMS, FISR also can create dynamic restoration plans even when the system is abnormal. Because FISR sends controls through SCADA, it does not require peer-to-peer communication between devices or rely on specific device manufacturers. Further, unlike traditional centralized schemes, FISR uses the as-switched ADMS model, so there is no separate model to build and maintain. These qualities quickly set FISR apart from traditional technology, making it a good fit for Alabama Power.

The FL application uses SCADA fault current magnitudes and the as-switched distribution system impedance model to calculate estimated fault locations. These locations are presented graphically as halos painted on the ADMS geographic, assisting operators and crews in patrolling. Distribution faults can be difficult to patrol because of the rear-lot construction of lines and limited nighttime visibility. By automatically calculating and painting halos, FL can significantly reduce the time it takes to patrol outages, leading to decreased outage time for customers.

The fault current magnitudes FL uses are reported by SCADA from substation feeder relays, line recloser relays and fault indicators. The configurable halos painted on the ADMS

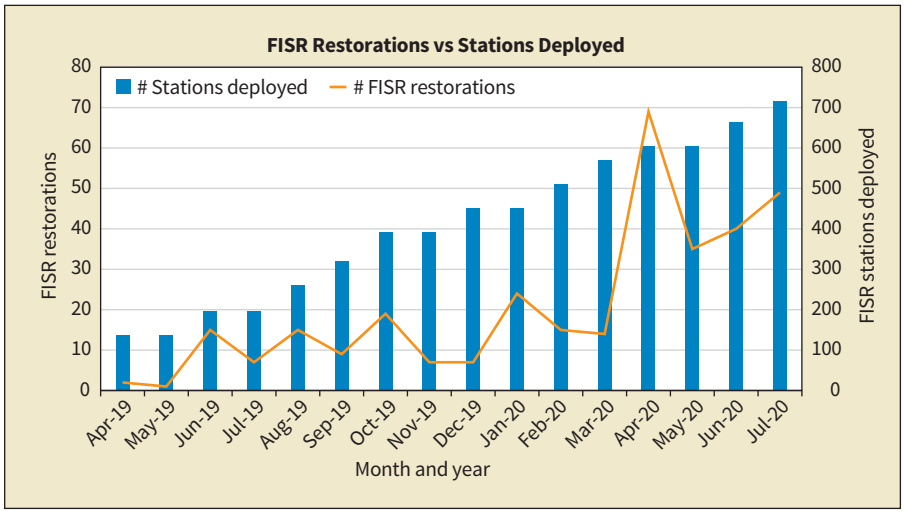
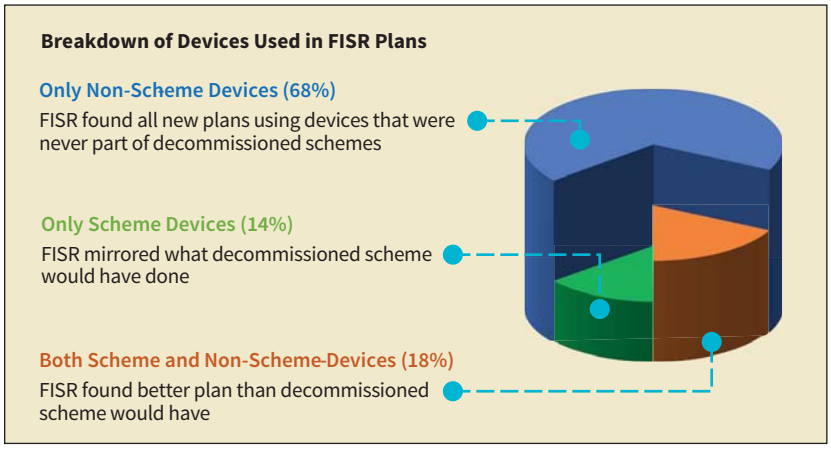


Chart showing the number of FISR restorations per month as more stations were deployed. The more stations that are deployed, the more tie switches FISR has available to use for restoration plans.



One characteristic that sets FISR apart from local schemes is its ability to use all automated devices. In 68% of the FISR restorations at Alabama Power, FISR implemented plans using only devices that were never part of local schemes. In 18% of the FISR restorations, FISR found a better plan that the decommissioned scheme would have were it still in service.

geographic are ±5% of the calculated fault location and remain on the geographic while the lines are deenergized.

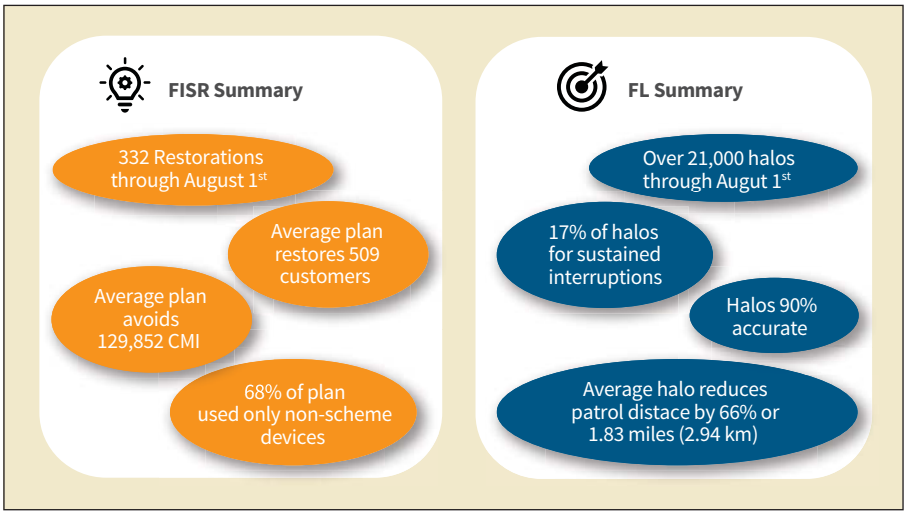
Deployment Strategy

Alabama Power began FISR deployments following a small pilot in Birmingham, Alabama, U.S., in 2018. To ensure realistic power flow simulations of proposed FISR plans, Alabama Power worked on improving feeder models before deploying FISR. These model improvement efforts included replacing bad SCADA sensors and field checking locations with suspect modeling.

Several reports were written to flag suspect data for end users to investigate. This is a departure from the way model data traditionally has been used. From SCADA measurements to Geographic Information System (GIS) conductor sizes, the model data now has real-time impacts on system restoration. FISR was deployed to approximately 60 substations every six weeks, which allowed time for this model improvement process to take place.

After the pilot concluded, FISR deployment was completed in 18 months for all system substations and feeders that were appropriate candidates for the technology. While there are particular customer conditions that make a substation or feeder ineligible for FISR, Alabama Power has been able to deploy it successfully to 98% of its customer base. The deployment area included more than 715 substations, 1,890 feeders and approximately 5,300 SCADA devices. In addition, more than 220 local schemes were disabled, with the devices being handed over to FISR. The more SCADA line devices that exist on a substation, the more opportunities in which FISR can assist during outages.

FL was deployed with distribution power flow in early 2018. Starting in 2019, Alabama Power began installing additional fault indicators just under the feeder breakers where no relay fault targets existed. Placing fault indicators at the feeder heads enabled FL to have visibility of all faults on the feeder. These installations proved much more cost-

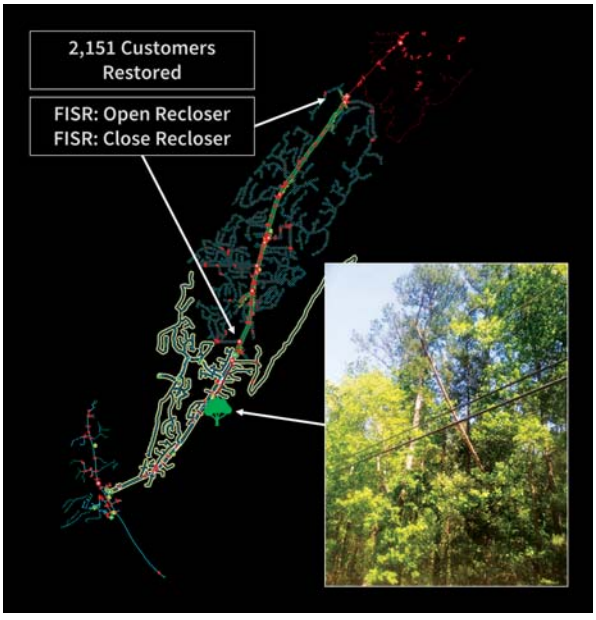


High-level summary of FISR and Fault Location performance since implementation through Aug. 1, 2020.

effective than upgrading older relays, while also giving end users engineering access to analyze fault data.

Real Results

When compared to local schemes that require events to be downloaded and evaluated manually, FISR greatly simplifies tracking results because it exists in the ADMS, which archives every evaluation and restoration. Through Aug. 1, 2020, FISR has restored customers 332 times successfully across Alabama Power's service territory, avoiding approximately 42.8 million customer minutes of interruption (CMI). The average FISR plan restores 509 customers and 3,867 kWh while avoiding 129,852 CMI.



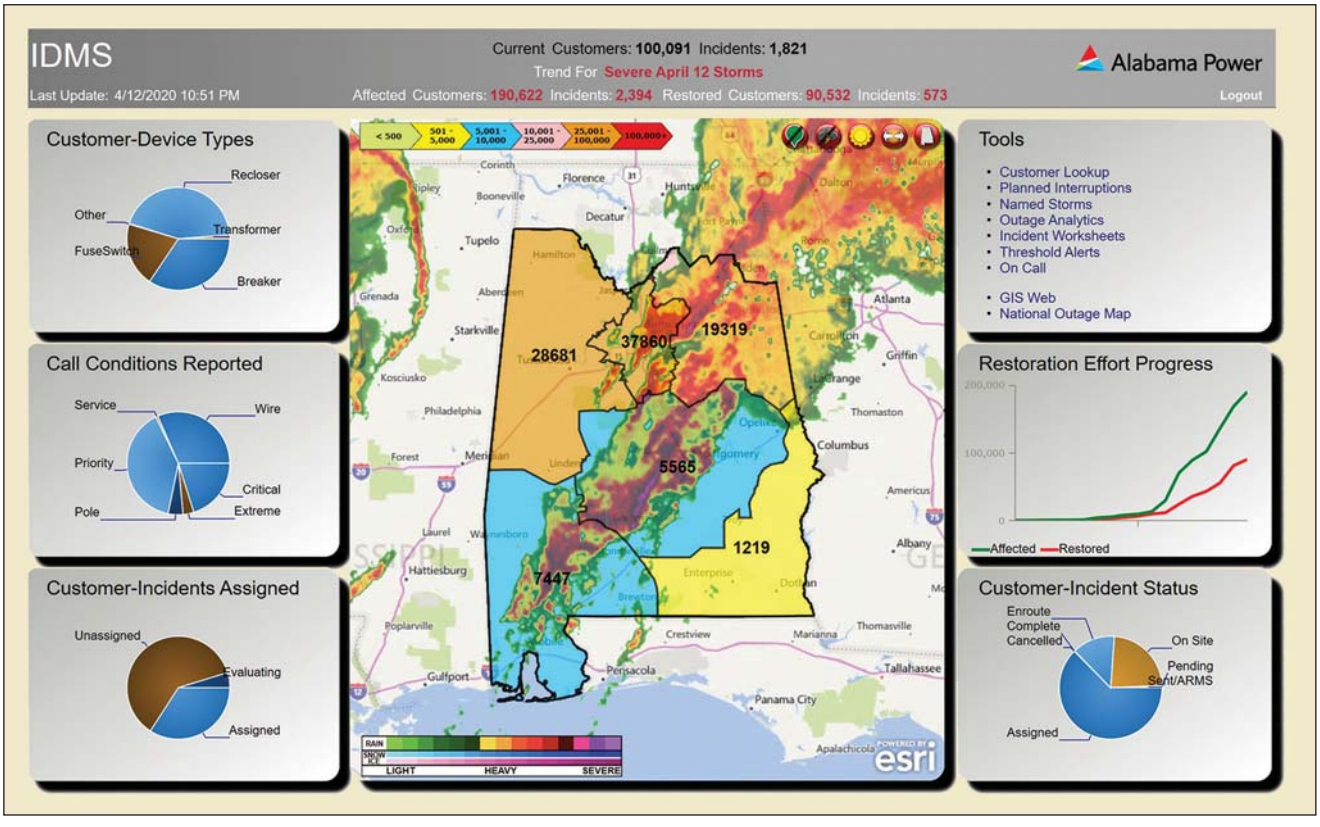
Recloser outage on Double Oak Mtn substation. FISR implemented a 2-step plan that restored 2,151 of 2,957 customers within 37 seconds of FISR starting evaluating.

When evaluating FISR's success, what especially caught Alabama Power's attention is 86% of the FISR plans used at least one non-scheme device. In this case, the term "non-scheme device" refers to a device that was not a member of the more than 220 decommissioned local schemes and handed to FISR. In other words, 86% of the time FISR was able to restore more customers than the decommissioned schemes would have.

Perhaps more impressively, 68% of the FISR plans used only non-scheme devices, meaning these restorations were only possible automatically with FISR. These statistics highlight the true potential of FISR — mobilizing automated devices to participate in restorations in which they were not able to previously.

As a case study on FISR's effectiveness, a major storm hit the Alabama Power service territory on April 12, 2020, affecting more than 312,000 customers, or over 20% of the utility's customer base. There were 23 confirmed tornadoes, which resulted in more than 2,000 spans of wire down and 460 broken poles.

During this storm, FISR implemented 31 restoration plans across the service territory, avoiding an estimated 11.8 million CMI. These FISR restorations had a particularly positive impact during the storm because they helped customers avoid outages during the abnormally prolonged restoration process.



IDMS Dashboard Snapshot of April 12 storms that impacted Alabama Power. During this storm, FISR implemented 31 restoration plans.

Feeder breaker outage on Bluff Park substation. FISR implemented a 6-step plan to restore 1,263 of 1,630 customers within 110 seconds of FISR starting evaluating, 48 seconds of which was just sending SCADA controls.

While this was a significant storm, it was only one of four major storms to hit Alabama Power that month. In April 2020 alone, FISR implemented 71 successful restorations.

A major concern for utilities in 2020 is the safety of their employees in the wake of COVID-19. Since March 16, 2020, Alabama Power has been implementing social distancing and other precautions on-site to protect its employees. To minimize the impact on efficiency when working storms and outages, ADMS advanced applications are helping to fill the gap to maintain reliable service to customers.

Of the 206 FISR plans implemented from March 16 through Aug. 1, 2020, 82 plans restored over 60% of the impacted customers, 128 plans avoided an estimated 50,000-plus CMI each, and 26 plans involved four or more switching steps. Each time FISR can restore customers and avoid outages that last for several hours, it has a positive impact on Alabama Power's customers. In total, these FISR restorations since March 16 helped Alabama Power to avoid an estimated 26.9 million CMI.

Although the FISR benefit of avoiding outages certainly is positive for the utility, avoiding outages is much more impactful for society. Per the U.S. Department of Energy's interruption cost estimate (ICE) tool, all FISR restorations combined avoided an estimated US$82.5 million for Alabama Power's customers. While a tangential financial benefit, there are very real impacts on business owners who must close early for the day or send employees home early as a result of an outage. Other benefits include time saved on not maintaining local schemes, improved employee safety by not having to switch lines manually and reduced employee time spent in the field.

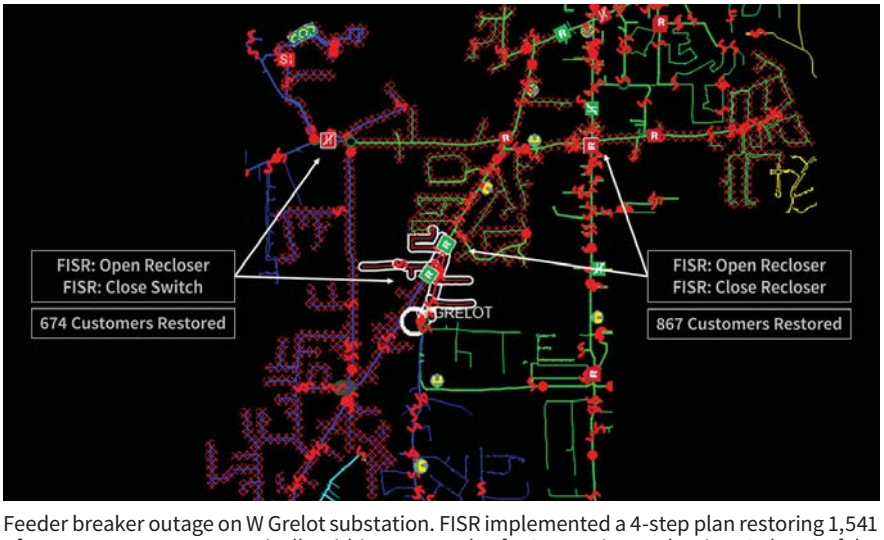
Through Aug. 1, 2020, FL has proposed potential fault locations over 21,000 times. Approximately 17% of these FL halos were for sustained interruptions, with the distribution control centers reporting a 90% FL accuracy rate. This high level of accuracy has encouraged operators to use fault halos whenever they are available, to the point where first responders take the initiative to ask operators what FL says before they begin patrolling an outage. On average, FL halos painted on the real-time ADMS geographic reduce the patrol distance by 66%, or 1.83 miles (2.94 km), which the distribution control centers confirm has reduced patrol time for outages. In total, FL halos painted on the real-time ADMS geographic have reduced the distance crews must patrol by roughly 6,655 miles (10,710 km).

In addition to operators in the control center, users evaluating in the field also have access to FL results in the form of a report that overlays the FL results onto satellite images and road maps. End users no longer need to run fault simulations on engineering software to take advantage of this data. Although it typically does not generate the same excitement as FISR, FL is having a significant impact on reducing outage times for Alabama Power's customer base.

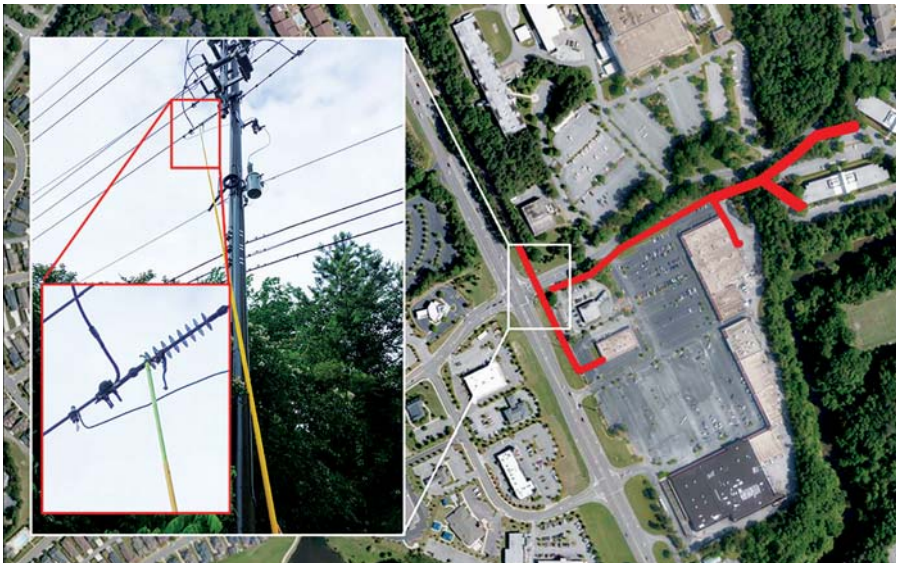
Lessons Learned

It is difficult to overstate how revolutionary FISR and FL have been to Alabama Power's approach to distribution. Many of the utility's modeling techniques, maintenance procedures and switching procedures had to be reevaluated to consider how FISR would behave or use the data.

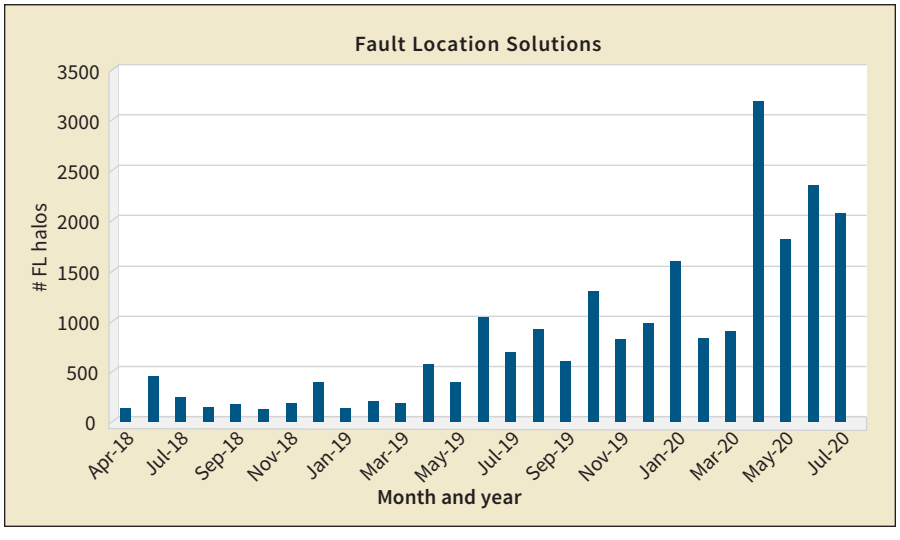
One lesson was the value of model integrity, especially in



Feeder breaker outage on W Grelot substation. FISR implemented a 4-step plan restoring 1,541 of 1,644 customers automatically within 74 seconds of FISR starting evaluating. Only 6% of the customers remained without power after FISR switched.



Fault Location halo on Chace Lake substation outage. Halos can help narrow down the patrol area for difficult-to-find faults, such as the snake on the bottom phase of the above switch. At night, faults such as this can be nearly impossible to find.



Fault Location halos painted on the ADMS geographic per month. Per the Distribution Control Centers, these halos have a consistent 90% accuracy and help reduce patrol time.

maintaining data after the initial model improvement. Because the distribution system is dynamic, changes are being made every day. When storms occur, it is difficult to keep track of all the changes made by line crews trying to get the lights back on as quickly and safely as possible. To combat this model drift, several reports were built that actively query GIS and ADMS models to flag suspected issues for investigation. Additionally, the philosophy that the districts know their areas best and should maintain FISR was adopted.

A surprising ally in maintaining models was distribution power flow, another advanced application in ADMS that was enabled at the same time as FL in early 2018. Distribution power flow quickly can identify where potential modeling issues exist that need to be investigated. Case in point, there have been quite a few times where distribution power flow correctly identified not only modeling issues but also system issues.

Another lesson was reinforcing the importance of including end users in all stages of development and testing. Involving users to help shape the look and feel of these advanced applications led to a positive reception when these tools were deployed to ADMS. The end users also identified potential issues and scenarios that could be addressed before the tools were deployed. They helped to champion the value of the tools, train others and answer questions.

On the vendor side, Alabama Power participates in GE Digital's working groups with other customers to ensure the applications continue to evolve positively.

Next Steps

The transformative success seen in just the first 24 months of advanced applications in the ADMS has changed Alabama Power's vision of distribution. FISR loss-of-voltage triggering is scheduled to be deployed within the year, where restoration plans will be implemented automatically during transmission outages. Another effort underway is the implementation of a Distributed Energy Resource Management System (DERMS) in GE Digital's ADMS, so renewable generation can be integrated successfully with the distribution system and FISR can keep better track of these loads during plan evaluation.

ADMS, FISR and FL have changed the Alabama Power's distribution approach, from the field to the office. It still has challenges to overcome, but the benefits realized by the utility's customers and employees as well as Alabama businesses have been nothing short of impressive. There is so much more to come. TDW

Matthew Leak (*mhleak@southernco.com*) is a senior ADMS Advanced Applications engineer for Alabama Power, providing technical leadership and support for Distribution Power Flow, Fault Location, and FISR. He earned his BSEE and is a professional engineer licensed in Florida. He transferred to Alabama Power in 2017 from Gulf Power where he served in various technical roles in distribution, including Reliability, Distribution SCADA, and Protection & Control.

For more information:
GE Digital | www.ge.com/digital/

Blue GIS being lifted to third floor of substation K.

Green Utility Installs Blue GIS

Norwegion DNO refurbishes a 1965 substation with environmentally friendly gas-insulated switchgear.

By **Ruth Helene Kyte**, BKK Nett AS

Responsible for operating the distribution network in Norway, BKK Nett AS owns several companies engaged in many different areas of the electricity business, including operating hydropower plants, district heating systems, charging stations for electrical vehicles and communication networks. With distribution network voltages ranging from 132 kV to 230 V, BKK Nett supplies approximately 250,000 consumers in a number of municipalities located in western Norway, from Sunnfjord in the north to Etne in the south. Although BKK Nett is a regional and relatively small distribution network operator (DNO) in comparison with global DNOs, in keeping with its service territory and the rest of Norway, it has a major focus on the local environment and the need to minimize CO_2 emissions in the transportation sector and other industries.

To meet this objective, the Norwegian government has introduced several fees to limit the total CO_2 emissions, especially in city centers around the country. Furthermore, the European Union is considering introducing fees to limit the emission of SF_6 gas, the insulating medium used in high-voltage switchgear. BKK Nett has taken a small step for the climate change facing the world but a giant leap forward for a small DNO by being the first utility to buy and install the climate-friendly blue gas-insulated switchgear (GIS) at the 132-kV voltage level manufactured by Siemens AG.

An Existing Substation

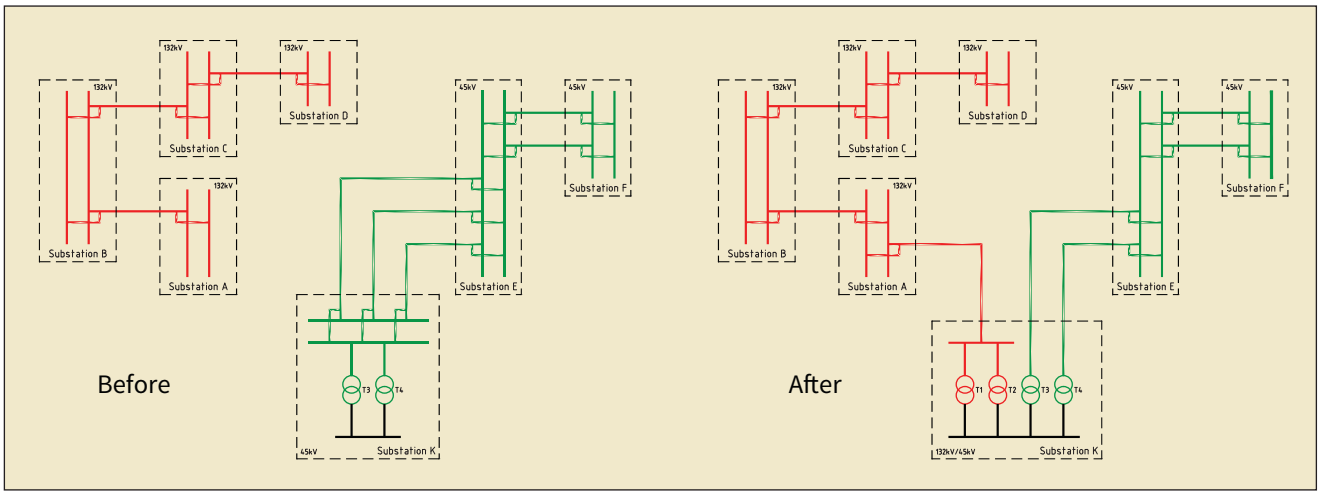
When commissioned in 1965, the 45-kV substation K was equipped with a 45-kV indoor switchgear comprising air-insulated circuit breakers, four 45/11-kV transformers each rated

at 20 MVA and an 11-kV indoor switchgear also equipped with air-insulated circuit breakers. Since then, BKK Nett had to remove two transformers and replace the 11-kV circuit breakers with new compact breakers. Nearing the end of its service life, the 45-kV switchgear also was due for replacement. Furthermore, in some extraordinary instances, the 45-kV circuit breakers required manual operation without the benefit of interlocking, because of the design of the breakers. This operational procedure does not meet today's safety standards.

BKK Nett had an established general strategy to upgrade the voltage level in the area from 45 kV to 132 kV to increase network flexibility and supply the increasing energy demands from its residential and business consumers. In line with this strategy, the DNO planned to replace the high-voltage switchgear and extend substation K with two 132/11-kV transformers. Following this refurbishment project, the substation would be equipped with two 45/11-kV transformers directly supplied from a nearby substation, two 132/11-kV transformers controlled by the new blue GIS switchgear and 30 11-kV feeders to supply consumers, including a shore connection to cruise ships.

Team moves blue GIS from platform erected outside substation into building.

This project coincided with a request from a large power consumer for an additional 32 MW, increasing their total maximum power requirement from 1.3 MW to 33.3 MW. This would require the consumer to be supplied at 11 kV. The consumer supplies cruise ships with a shore connection and is experiencing an increase in the number of cruise ships that require an electrical shore connection while docked at the port. The ships that berth in a bay close to substation K each would be able to request a power supply ranging from 3.5 MW to 12.5 MW for the periods they are in port, thereby eliminating the need to have their diesel generating facilities in operation.



Single-line diagram showing 132-kV and 45-kV systems before and after voltage upgrade project.

Blue GIS Selection

Because of the location of substation K and the planned voltage upgrade, expectations of the leaders at BKK Nett and the government were for the substation to be climate friendly. In addition, there was an opportunity for the substation to reduce the environmental impact of the transportation/tourism sector by providing power supply services to visiting cruise ships.

According to the Norwegian Environment Agency, SF_6 is 22,800 times more pollutive than CO_2. BKK Nett—which focuses on being a green company—seeks green choices for the future. Therefore, with its substation K refurbishment project, the DNO decided to consider the complete range of climate-friendly GIS being promoted by several high-voltage switchgear manufacturers.

BKK Nett chose to sign an agreement with Siemens because of its technological design and the use of vacuum as a switching and interruption medium together with clean air as the insulation medium. Siemens calls this blue GIS. Clean air, or purified air, comprises a mixture of 80% nitrogen to 20% oxygen. The use of these known mediums makes it more predictable regarding safety during maintenance and avoids any eventual restriction using a new type of gas as an alternative.

The blue GIS would control the main distribution network feeders that supply the substation, thereby also supplying cruise ships with a shore connection to reduce the local pollution from the ships while in port. This makes the power to these cruise ships green energy entirely, from the hydropower plants and transmission system to the distribution network and cruise ships. This objective proved to be a suitable site to consider substation K as a pioneer substation equipped with blue GIS.

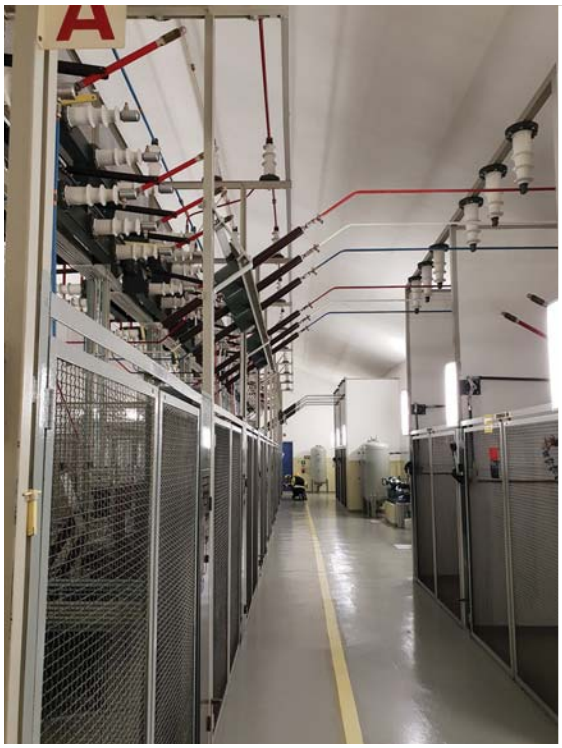
The contract with Siemens to supply, engineer and commission the blue GIS as well as install the protection system and 11-kV feeders was signed in November 2018, with a planned delivery to site of the new blue GIS in October 2019.

Substation Upgrade

BKK Nett has a responsibility to supply both existing and new consumers with the power they demand. Fortunately, the utility had prognosticated an increasing demand for power to supply the cruise ships by a shore connection. It started preparing for this several years ago by upgrading and expanding an existing adjacent substation from 45-kV to 132-kV voltage level. The adjacent substation A was equipped with new transformers and new 132-kV switchgear, including provision for an additional 132-kV underground cable feeder for substation K.

The route for the future 132-kV cables to substation K also was established. Under construction for 10 tears, the cable duct from substation A to substation K is more than 2 km (1.24 miles) long, crossing a city center. When excavating the cable duct run for the 132-kV cables, ducts for 11-kV cables, communication cables, district heating, water and wastewater services were installed at the same time. The mutual cooperation by the utilities responsible for the other infrastructure services installed underground ensured the cable route was established with a minimum impact on the local environment and the citizens of the city.

The contract for the new 132-kV blue GIS, with a rated cur-



(Left) Air-insulated circuit breakers before replacement. Incoming oil cable terminations shown on right. (Right) Empty switch room prior to installing blue GIS. Earthing system underneath blue GIS is shown in floor.

rent of 3150 A and a short-circuit rating of 40 kA, included two transformer bays and one cable bay with provision for several bays in the future. The blue GIS is rated for 145 kV and has the same mechanical characteristics and dimensions of a regular 170-kV GIS with SF_6 gas. However, the dimensions, weight and placement of the new GIS in the existing high-voltage switch room in the substation was an issue. The dimensions of the switch room were on the borderline of being too small to accommodate the new blue GIS in addition to the new incoming 132-kV cables and their increased bending radius.

To release some of the available space, BKK Nett installed a new technology to replace conventional current and voltage measurement transformers: low-power instrument transformers (LPIT). LPIT technology makes it possible to flexibly parameterize the measuring and protective systems according to specific requirements. Transmitting the data over a fiber-optic cable reduces the length of wiring required, but there is no backup solution with the conventional measuring and protection systems used. As a bonus, the GIS dimensions and overall

Blue GIS installed in switch room. Incoming cable is over blue GIS and transformer cables exit switch room through wall on left.

weight with LPITs was reduced by 20% compared to a GIS with conventional measurement transformers. Nevertheless, BKK Nett had to calculate the static and dynamic strength of the building to confirm it could handle the weight and forces during a switchgear breaking operation.

In addition to removing the existing 45-kV circuit breakers from the switch room, the substation civil works also required some adjustments to the building. The oil-pressure system and housing for the existing incoming oil-filled 45-kV cables had to be removed. Further work also was required to install a new earthing system in the floor construction for the GIS, a transportation door to get the GIS into the switch room, holes for new incoming 132-kV cables, holes for new 132-kV transformer cables and a roof crane to replace vacuum tubes in the circuit breakers, when the need arises in the future.

All the reconstruction works and reported issues were known and programmed in advance. In fact, the new blue GIS with LPIT proved to be more suitable for use in the existing substation because the design was more compact than conventional GIS. Furthermore, BKK Nett will have a long-term benefit in terms of reduced maintenance cost, as it no longer needs to consider all the safety procedures associated with maintaining components containing SF_6 gas.

Project Organization

BKK Nett appoints a project manager for its major construction works who is responsible for all outsourced contractors. For the substation K project, the engineering and civil works were undertaken by Sweco Norway AS and Minimaskin AS. BKK Enotek AS, a daughter company of BKK AS, completed the engineering and commissioning of the incoming 132-kV cable and 11-kV cables, while BKK Nett installed the cable duct from the nearby substation to the consumers. The project cost some 60 million Norwegian krone (US$5.9 million).

From the time BKK Nett started discussing the application of climate-friendly switchgear to the completed commissioning of substation K in May 2020, a period of two years elapsed. The well-managed numerous resources worked together successfully on the first installation of blue GIS, which has drawn global attention to the small DNO in Norway.

Low Power Instrument Transformers

Likewise, LPITs are a new technology that has had a limited number of applications to date. BKK Nett encountered some difficulties with the configuration of these new protection systems. Siemens has continued with further development so protection systems can take full advantage of LPITs. However, because of the project schedule, the latest version of LPITs has not yet been implemented in substation K's protection system. LPITs are an important step forward to establish a digital substation, the direction BKK Nett wants to go with substation K.

BKK Nett has been a pioneer in erecting a digital substation in another recently completed project. In this substation, the installed conventional transformers use a merging unit in the outdoor switchgear to reduce the copper wiring to a minimum. Fiber-optic cables connect the merging unit to the control system.

The adoption of these new green technologies are forward-thinking decisions for a small DNO like BKK Nett. However, the utility has a conscious attitude toward making decisions that facilitate green solutions all the way from climate-friendly hydropower energy production to end consumers. BKK Nett aims to lead by example by contributing to a more climate-friendly society. TDW

Ruth Helene Kyte (*Ruth.Kyte@bkk.no*) holds a master's degree from the Norwegian University of Science and Technology and has nine years of experience in energy management and engineering. For the past three years, she has worked as project manager on major construction projects at BKK Nett AS, including the substation K project.

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Electricity as a Fuel

Electrification is expanding beyond personal electric vehicles to heavy-duty trucks, seaports and even airports.

By **Jeff Postelwait,** Editor

When people think about electricity as a transportation fuel, they normally think about it in the context of moving people around by electric cars, trucks, mass transit and buses. However, there also is a growing interest in electricity as a more efficient and cost-effective transportation fuel for moving things, like shipping freight, last-mile delivery of goods and even powering seaports.

While it is true more consumers are buying personal electric vehicles (EVs) — an 81% increase from 2017 to 2018, according to the Edison Electric Institute (EEI) — some utilities are pursuing projects to electrify transport in other ways. Green fleets could cut emissions while costing 30% less to operate than combustion engine vehicles, but they also might require investing in some power grid upgrades to get them working properly.

Swedish automaker Volvo did a survey in 2018 that confirmed people are still concerned about EV range. In fact, 58% agreed they have range anxiety, in which they fear a vehicle has insufficient range to reach a given destination. People also are apprehensive about where the nearest charging station is, with 49% worried about charging availability. However, the automotive company itself is betting big on EVs. Volvo Trucks North America is rolling out its first Class 8 battery-electric vehicle in 2020 as a part of its Low Impact Green Heavy Transport Solutions (LIGHTS) program.

Powering Through Barriers

Keith Brandis, Volvo's vice president of partnerships and strategic solutions, told attendees of EEI's 2020 Virtual Leadership Summit on fleet electrification that electric trucking is taking off.

"The future is happening now. A couple years ago, there were start-ups and other companies that predicted that electric trucks would be right around the corner, and they failed. But for Volvo, a company of 100,000 people, to say we are going to go into heavy electric trucks … it's happening and we're saying now is the time to be having these plans about grid upgrades and charging infrastructure," Brandis said.

An electric heavy-duty truck recharges. Credit: Haiyin, Dreamstime.

There are barriers to overcome. For example, Brandis said in EV-friendly California, it can be hard to get public charging stations in place for heavy-duty trucks. There has been uncertainty about whether operators of EV service equipment are considered public utilities under the Public Utilities Code. Volvo has been working with other companies since 2019 to get clarification on this classification from the California Public Utilities Commission (CPUC). In August 2020, the companies asked the CPUC for "an exemption for medium- and heavy-duty EV charging services from classification as public utilities to address real concerns that are holding up the financing and completion of projects currently nearing completion, or in various phases of development and construction, to serve medium- and heavy-duty EVs. The CPUC

A FedEx all-electric truck in Lower Manhattan. The delivery company added Nissan e-NV200 vans to its delivery fleet in 2014 as a part of its EarthSmart program. Credit: Zhukovsky, Dreamstime.

issued a decision on Sept. 24, 2020, stating: "The providers of medium- and heavy-duty electric vehicle charging services, and off-road electric vehicle or off-road electric equipment charging services, are not public utilities."

This clarification should help with the completion of more heavy-duty charging stations. Another reason this should be less of a barrier in the coming years is the California Air Resources Board (CARB) voted on June 25, 2020, to approve an Advanced Clean Trucks regulation. According to the new rule, every new truck sold in California will be zero emission by 2045. There also is a proposed requirement for larger fleets in the state to transition to electric trucks year over year.

Utilities such as San Diego Gas & Electric and others have filed with the CPUC for more support on deploying medium- and heavy-duty electric trucks. The CPUC began reviewing these applications in spring 2018 and continues to gather input from utilities and other stakeholders.

Another obstacle is the power grid itself. A large trucking distribution center would use a few hundred kilowatts mostly for lighting and some light-office activity. That same center, if it had a fleet of long-haul trucks to charge overnight, would now require electricity on the megawatt scale.

Russell Musgrove, managing director of global vehicles for FedEx, said his company recently ordered 1000 medium-duty all-electric panel vans from Chanje, a California-led, Chinese-based company. However, to reach the scale FedEx wants, more power will be needed, he noted.

"A lot of times, there's just not enough energy and, when you talk about putting 150 [or] 100 electric vehicles inside a building, we're having to be real creative with the kinds of charging systems we use," Musgrove explained. "Right now, we're actually having to scale back until we can get the kind of utility upgrades or microgrids to allow us to be able to have a whole facility using electricity as a vehicle fuel."

Working with utilities requires a familiarity with things delivery companies usually do not have to think about, he added.

"We are now focusing on working with our utility partners, and utilities are a very complicated industry. …I come from a simple industry. We move packages around the world on a 24-hour cycle, but the utility industry — regulated, deregulated — is very complex," Musgrove observed.

FedEx remains dedicated to proving the concept of electric shipping and delivery because the company believes electricity is the best fuel, according to Musgrove.

"I like to say we are energy agnostic, but in our duty cycle — in what we do, which is last-mile delivery — electricity is the most efficient energy source for a vehicle fuel that we could

A Volvo 7900 Electric Hybrid bus at the quick-charge facility on Bahnhofplatz Square in Zurich. Buses of this type use electrical power coming from accumulators for normal operation mode and can switch to a traditional engine if necessary. Credit: Denis Linine, Dreamstime

Port Fourchon, Louisiana is a major hub for the offshore oil and gas industry in southern Louisiana. Credit Shane Adams, Dreamstime.

find," Musgrove said.

Brandis believes battery technology for vehicles is evolving rapidly and offers big advantages over the long term, but upfront costs are still an issue.

"Seems like every 18 to 24 months, we see tremendous improvements in the efficiency and storage capacity of the battery, and the costs are coming down, but it still is the most expensive piece of a heavy-duty truck," he explained. "It's not just taking a diesel engine out and putting a battery in its place. It's many times more expensive."

Also at issue are end-of-life questions for this expensive hardware, which Brandis said must be part of the consideration for companies looking to invest in energy storage technology.

"We are also having to think about how do we get a second life for these very expensive components. What happens when the deterioration of the battery gets to such a point that it needs to be replaced? We are looking at how older batteries can have a second life providing power support to multifamily dwellings and apartment buildings," Brandis noted.

Marine Electrification

A tremendous amount of shipping is still done with ships crossing oceans. At any given time, there are at least 20 million shipping containers floating across the world's oceans. When the ships are in port, typically they must run their auxiliary engines. However, it is possible to retrofit ships to accept electricity from the power grid.

At Louisiana's Port Fourchon, the state's southernmost port, Entergy Services LLC and its innovation center, KeyString Labs, conducted their first shore power installation project. This port sits on the Gulf of Mexico and services some 90% of the Gulf's deepwater oil production, making the facility essential infrastructure of nationwide importance.

Entergy's shore power project works a bit like a miniature parking lot with charging stations for ships. It allows large platform supply vessels to park dockside and use grid power without having to burn fuel and run their engines. This is quieter, cleaner and cheaper than using auxiliary engines, and it causes no wear and tear on ship engines. To reap all these benefits, however, grid upgrades were necessary.

Existing power distribution lines had to be extended to reach closer to the shore, and 750-kV step-down transformers were mounted on platforms. Ship engineers plug a custom extension cord to the ship's electrical bus when power is needed, then signal onboard equipment to stop drawing power from the engines. Entergy also presided over a power quality test to ensure voltage stayed consistent while the ships drew power.

Entergy believes this application could be used in future projects. The utility already has changed its distribution standards to accommodate permitting for shore power projects. From a construction standpoint, Entergy developed a plan to lift five transformers to the special platforms along the shore and learned to bring the design and construction teams together during early project stages.

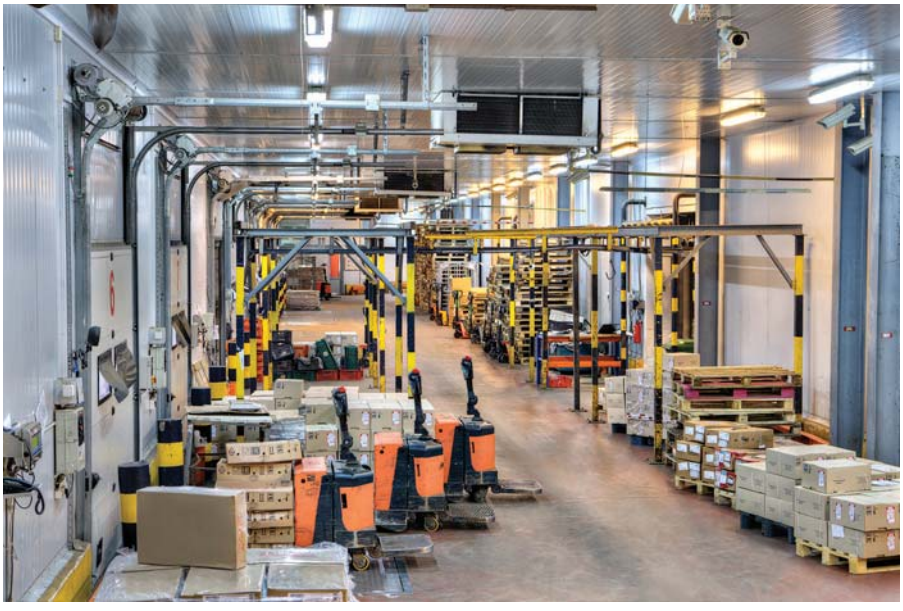
Edison Chouest Offshore, the marine transportation company whose vessels now charge while docking at Port Fourchon, had used smaller-scale shore power applications before. This kind of cross-industry cooperation and sharing of expertise could serve as a lesson for future projects as well as other transport electrification use cases.

Moving Freight with Electricity

Dallas/Fort Worth, Texas, U.S., is a crossroads not just for air travelers, but also for freight moving across land and air. The airport, which is the size of the island of Manhattan, shipped 971,000 tons of cargo in fiscal year 2019. Texas is synonymous with fossil fuel production and processing, but if a major world trade hub like DFW saw a major disruption in the oil and gas sector, all those goods coming and going through Texas might have a serious problem.

Dallas-based Oncor Electric Delivery Co., a public utility serving 10 million Texans, is thinking about what electrification could have to offer DFW. To enable more electric transportation, distribution centers are going to need more power.

T&D World contributor David Treichler, director of strategy and technology for Oncor Electric Delivery, said most distribution centers only use about 200 kW or less for lighting and offices. Fueling a fleet of about 40 Class 6 or Class 8 electric heavy-duty trucks would require around 9 MW. Current loads are an order of magnitude smaller than they would be in a distribution center that could charge electric trucks. Furthermore, if the distribution centers are clustered together to be close to transportation infrastructure, like airports and highways, the same substation might see its load rise dramatically.



Workers in a warehouse in St. Petersburg, Russia. Most warehouses use relatively small amounts of electricity but charging trucks at warehouses could change all that. Credit Vladimir Grigorev, Dreamstime.

Utilities interested in jumping into this kind of electrification may find themselves having to get familiar with how the logistics industry works. Treichler said Oncor found that fleet transition to electrification will be an annual load increase utilities will need to anticipate. Also, equipment manufacturers are considering different charging use cases for their vehicles. The overnight charging model uses lower-level direct-current (dc) fast chargers. However, trucks standing still to charge do not make any money. By using higher kilowatt dc fast charge, another model is to charge trucks as they are loading and unloaded at the depot. Depending on how the distribution center operates, either model could lead to higher peak-time loads.

Oncor developed a fleet analytics tool, called FleetSeek, and deployed it in the Dallas/Fort Worth area to gather data on the movements of trucks, their charging times, their impacts on residential feeders in the area and other data. The tool keeps track of some 21,600 fleets — some with two vehicles and some with hundreds. The utility believes green fleets could have a big impact on the power grid and even determine its future upgrades and growth as time goes by and more data is gathered.

Utility Partners

Russell Musgrove said FedEx is no longer in the "science project" phase of electrifying its fleet. The company already has seen enough data to be convinced electricity is an efficient fuel for delivering packages. What it needs now are dedicated utility partners. "I've been blessed to do some amazing projects with some utility companies on both the East and West Coasts," Musgrove said. "Some were true business partners, and some others were kind of my way or the highway."

Some utilities have gotten into the conservation mindset and electrified transportation consumes much more electricity in a sector where there used to be not much demand. Musgrove said all stakeholders need to get in the same room and understand one another's needs.

FedEx wants to expand its electric-powered fleet to tens of thousands of vehicles as quickly as possible, Musgrove said, adding that he does not want to keep things small. "We need to find OEMs and other start-ups that are becoming serious about getting to some level of scalability for tens of thousands of trucks as opposed to 100 here and 100 there," he explained.

These projects constitute a bigger step than they may seem. Electrifying operations at these sites goes far beyond a few charging stations at the local strip mall or a solar-powered parking lot on a college campus. Port Fourchon and DFW are critical infrastructure for the U.S., and a disruption at either could have wide-ranging economic consequences. This is a lot to trust the utility sector with, and it speaks highly of the trust stakeholders have in this industry to be tasked with such important jobs. If utilities can work together with everyone concerned, the way work gets done in the U.S. could be powered differently. TDW

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The island of Seogeochado where the project is based.

DC Distribution System on an Island

The energy efficiency of a Korean island's power system improves by more than 10% with a dc distribution system while maintaining reliability.

By **Jintae Cho** and **Juyong Kim**, KEPCO Research Institute

At the 1893 Chicago World's Fair — held in celebration of the 400th anniversary of Columbus' discovery of the American continent — as U.S. President Cleveland pressed a button, 250,000 light bulbs lit up the fair. The electricity used for this memorable event was an alternating current (ac) invented by Tesla, and Edison's direct current (dc) has gone downhill ever since. In the 20th century, electricity generation was dominated by coal, gas and hydropower using rotating turbines. The electricity was generated with ac because electrical power could be transmitted over longer distances with lower losses.

Now, in the 21st century, photovoltaic power generation, hydrogen fuel cells and the representative renewable energy sources generate dc. In addition, most electronic appliances like refrigerators and washing machines use dc. Cell phones and lithium-ion batteries in electric vehicles (EVs), with 18.7 million U.S supplies expected by 2030, also use dc.

As the current power system adopts ac transmission as the standard, dc electricity generated from solar power, wind power and fuel cells is converted into ac, which is then converted back to dc through ac-dc converters installed in the home and mobile devices. Even under the assumption the conversion efficiency of each stage is on the high end at 90%, Korea Electric Power Corp. (KEPCO) estimates a power loss of approximately 30% occurs after undergoing three stages of conversion and reconversion.

DC Distribution System

To reduce the power loss that occurs during the conversion process, a dc system is proactively introduced by internet data

ARABIC 1, in the section titled "DC Distribution System". Configuration of low-voltage dc distribution system on an island.

centers (IDCs), which consume considerable power. In 2008, Lawrence Berkeley National Laboratory demonstrated a dc distribution system has the potential of using 28% less energy than the typical ac system. In Korea, a dc-based telecom data center also demonstrated a 13.2% improvement in efficiency with the implementation of a dc distribution system.

With internet access and operation as its main function, an IDC consumes electricity on a vast scale. On a global scale, its power consumption is up to 3% of all electricity generated on the planet. Its power facilities, cooling equipment, and air-conditioning systems are operated 24 hours continuously each day to ensure stability and reliability of the center.

There have been several challenges in deploying dc systems. When voltage is low, the resistance loss of dc systems increases. Thus, the wire needs to be thickened, which inevitably results in increased cost. On the other hand, when the voltage is high enough, such as several kilovolts, problems such as arc or electric shock can occur. Safety and protection are two of the main

ARABIC 2, any placement in final two sections. Human-machine interface screen of low-voltage dc operation system.

Customer facilities including EV charger and dc lights.

concerns associated with dc distribution. It can be challenging to break a dc fault current compared to an ac current because dc currents do not cross a zero point. It is during a zero crossing of the current waveform when fault interrupting devices can break the currents.

In the case of ac systems, as its voltage crosses zero point about 100 times, the arc is eliminated spontaneously and immediately. However, because the dc system maintains constant voltage at the rated value, the arc is sustained. The undesired arc can cause substantial damage and harm, and even lead to a fire. To address these problems related to optimal voltage and safety, an on-site demonstration test of the dc distribution system and standardization are essential.

Demonstration Projects

Since 2007, the Nippon Telegraph and Telephone Corp. (NTT) in Japan has been conducting an on-site demonstration project of the dc distribution system as well as a campus-scale experiment with 380 V dc. The Electric Power Research Institute (EPRI) developed an intelligent, multifunctional transformer capable of dc supply at various voltages. The prototype was produced in 2009. In addition, ABB constructed a dc distribution system on a ship to reduce fuel consumption by 10% or higher. While there has been much interest in dc distribution systems, this system implementation is still carried out at the level of demonstration projects.

The Seogeochado dc island construction project, conducted by KEPCO Research Institute, is currently the world's largest dc distribution network demonstration project. In this system, instead of ac, dc power lines of 1500 V are constructed and dc generators — such as solar power generators, wind power generators, batteries and diesel generators — are interconnected for domestic electricity supply. In addition, light-emitting diode (LED) streetlights, electric cars and charging stations are installed for residents in the region.

Because of the growing number of solar power and energy storage systems (ESSs) that generate dc as well as the increase in LED lighting, digital devices and EVs that consume dc, dc distribution technology has been developed for energy efficiency by connecting directly to dc without having to convert to ac. With the spread of renewable energy sources and an increase in digital loads, demand for a dc power grid is increasing. To spearhead the dc distribution system business, KEPCO has constructed a dc island. While still in an early stage globally, the dc island has operated successfully in a pilot.

Less Conversion, More Efficiency

The KEPCO Research Institute designed dc-based electric power sources, renewable sources, customer facilities and distribution lines. Then it developed an integrated operation sys-

tem with a dc distribution system and applied it to the island's power grid. Instead of the 6.6-kV ac in Seogeochado, a 1500-V dc (±750-V) distribution line — as well as a solar power generator (200 kW), a wind power generator (100 kW), an ESS (1.5 MWh) and a variable-speed diesel generator (200 kW) interconnected with the dc distribution line — was built. The dc-generated power was supplied to residential homes.

By reducing the power conversion loss of renewable sources and home appliances, the efficiency of the power system's energy use improved by more than 10% and stable dc power was supplied to customer in the pilot. As a result, KEPCO Research Institute is speeding up the standardization of its dc distribution system as well as its large-scale on-site experiments. In March 2020, a memorandum of understanding was signed with the Korea Electronics Technology Institute, where organizations announced their commitment to research collaboration in the field of dc distribution system operation technology and standardization technology that can be applied to solar power, batteries and the internet of things market.

In 2020, for the dissemination and commercialization of dc distribution, a 1-MW DC power supply system construction project for supplying power to dc building will be launched. "KEPCO Research Institute plans to continue investing in the demonstration and standardization of the dc distribution system," a KEPCO official commented. "We aim to contribute to the government-driven solar power and hydrogen fuel cell projects."

When the demonstration test and standardization process at the Seogeochado dc distribution system are completed, dc-based distribution systems with renewable sources will start to be deployed throughout Korea. TDW

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Juyong Kim (*juyong.kim@kepco.co.kr*) leads distribution planning group at KEPCO Research Institute. He is responsible for low-voltage dc distribution and dc microgrid projects in Korea and is also developing the management system for the medium-voltage dc distribution system with interconnection of large-scale renewable sources and digital loads. He received his master's and Ph.D. degrees in electrical and electronic engineering from Kyungpook National University, Daegu, Korea, in 1994 and 2007, respectively. He joined KEPCO in 1994 and has 27 year of experience in the power distribution industry.

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Actual Power Quality

Enexis invests in a measurement program to fully understand the performance of its distribution network.

By **Sharmistha Bhattacharyya**, Enexis Netbeheer B.V.

To promote the sustainable-energy transition, an increasing number of photovoltaic rooftop panels and wind turbines are being connected to low-voltage and medium-voltage networks. The integration of these renewable sources of generation has changed the existing distribution network configuration into being a more decentralized grid, introducing voltage quality problems on the network. At the same time, the need for electrical energy continues to increase because of the demands imposed by charging electric vehicles (EVs) and heating loads such as heat pumps.

Additionally, over the last two decades, residential customers have been using more electronic appliances that require a pure sinusoidal voltage waveform for trouble-free operation, but they have a negative impact on voltage quality because of the injection of distorted currents at the point of connection (POC). Therefore, maintaining voltage quality in compliance with regulatory standards can be a big challenge for distribution system operators (DSOs).

Enexis Netbeheer B.V. is the second largest DSO in the Netherlands, supplying electricity to more than 2.8 million customers in the northern and southern parts of the country. Over the last five years, the utility has invested in a comprehensive power quality measurement (PQM) program to monitor voltage variations, voltage flicker and harmonics to fully understand the actual power quality (PQ) performance on its high-voltage (HV), medium-voltage (MV) and low-voltage (LV) networks. As part of this program, for the POCs of approximately 1000 customers — less than 0.04% of its customer base — who have complained, Enexis monitors and measures the actual supply voltage quality to ensure the parameters comply with European Standard EN 50160 and Dutch Grid Code. When needed, it takes appropriate remedial measures to restore voltage quality at a POC.

Field measurements for national level PQM campaign using Fluke 435 –II meter.

Voltage Quality

Enexis' reliability of supply has been relatively high over the last few years. In 2019, its system average interruption duration index (SAIDI) was 14.2 minutes compared to the national average of 19.8 minutes. The customer complaints received have been more frequently linked to various supply voltage issues. These customers may have problems because of overvoltage or undervoltage issues, improper functioning of or damage to installed appliances, frequent blowing of lamps and fuses. Other voltage-related complaints have included unwanted tripping of the inverter systems in the photovoltaic (PV) rooftop panels and a flicker experienced on dimmer-controlled lamps.

When a customer makes a voltage complaint, an Enexis engineer analyzes the problem and discusses the complaint in more detail with the customer, if necessary. In many cases, PQ measurement equipment must be installed at the customer's POC for a short duration or week-long period. In practice, over the last five years, only 20% to 25% of the voltage quality measurements collected have violated the European Stan-

A per annual report of 2019:

Total conections: 2,849,000

Total yearly energy demand: 33,759 GWh

Yearly average outage time: 14.2 minutes

Total connected cable lengths: 141,100 km

Utility service areas of Enexis in the Netherlands.

dard EN 50160 and Dutch Grid Code boundary conditions. The Dutch standard specifies similar limit values as those in EN 50160 (95% of the time) for the PQ parameters. However, the Dutch Grid Code specifies much stricter limits for voltage flicker and harmonics (100% and 99.9% of the time, respectively).

PQM Analysis

Based on the Enexis database statistics for the five-year period of 2015-2019, it is evident the DSO's main PQ problems are because of light flickering and voltage variations. Customers located in rural areas often are connected to long isolated networks remote from the source transformer substation. These customers suffer mainly from low voltage and light flicker problems. On the contrary, customers located in cities mainly complain about the occasional high voltage (on sunny days) at their POCs, especially when many customers in the same neighborhood have rooftop PV panel installations.

From the measurements recorded, Enexis has identified specific harmonics (such as the odd triplen harmonic values of the 15th and 21st order) violate the standard boundary limits at some of the customers' POCs. Also, because single-phase services are not evenly jointed to the three-phase underground LV cable, the load distribution between the three phases is unbalanced, causing voltage asymmetry in the network. In general, Enexis' complaints can be allocated as follows:

- 50% light flicker problems
- 30% voltage variations
- 20% individual harmonics, total harmonic distortion (THD) for voltage and asymmetry issues.

PQ problems often are complex in nature. It is not always easy to find the origin of a problem because of the interactive behavior. Customers' electronic equipment injects nonlinear currents into the network that may adversely affect the sinusoidal waveform of the supply voltage. In turn, this distorted voltage waveform can cause a more negative impact on a customer's appliances.

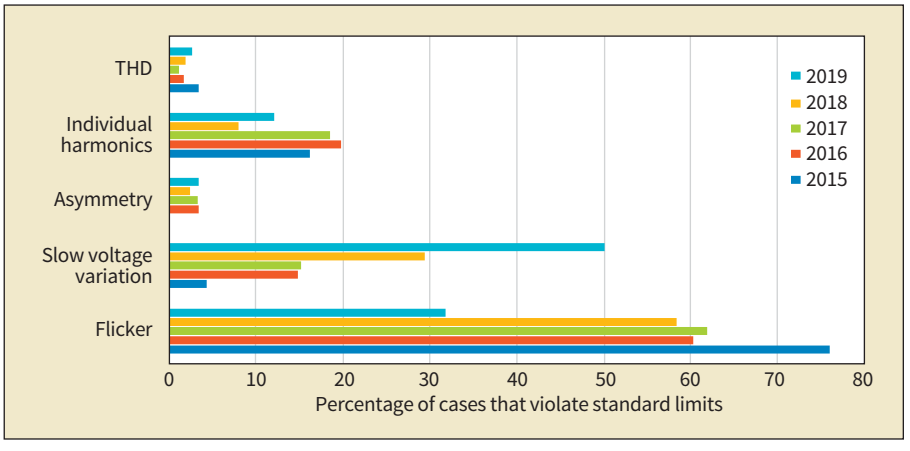
Based on analysis, Enexis found 75% of PQ problems originate in the underground LV cables because of short circuits from excavation activities. Around 15% of PQ problems are at the customer's own installation. Another 8% of the problems originate from a nearby neighbor's installation. The source of the problems for the remaining 2% of the complaints cannot be accurately identified.

Enexis also pinpointed most of the complaints come from residential customers. Small business customers (for example, agricultural businesses) are the second largest group to submit complaints. Also, the DSO noticed the number of complaints from customers who have rooftop PV installations has been increasing annually.

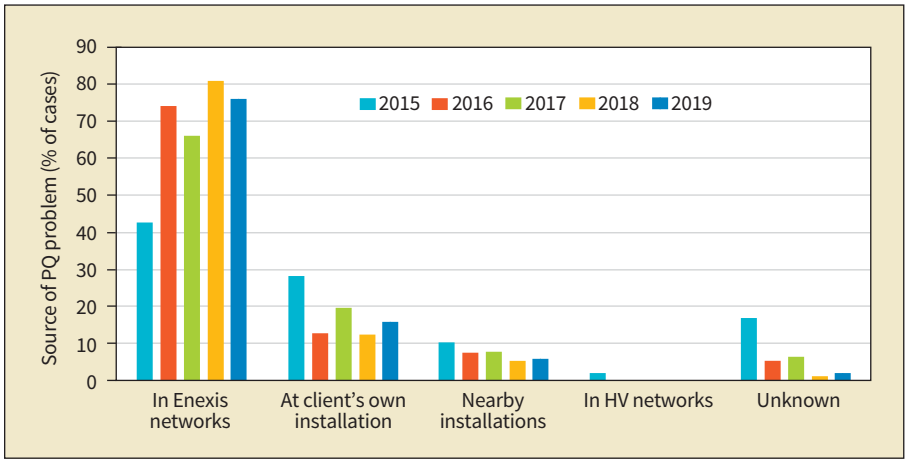
Mitigation Approaches

Enexis only conducts PQM at the customer's POC after verifying the complaint is justified. Following the PQM, the data is analyzed to identify the type of PQ problem and the probable source. Sometimes, network analysis (using a simulation tool) also is performed to understand the problem before deciding on a proper mitigation action. This generally requires consultation with the asset management team.

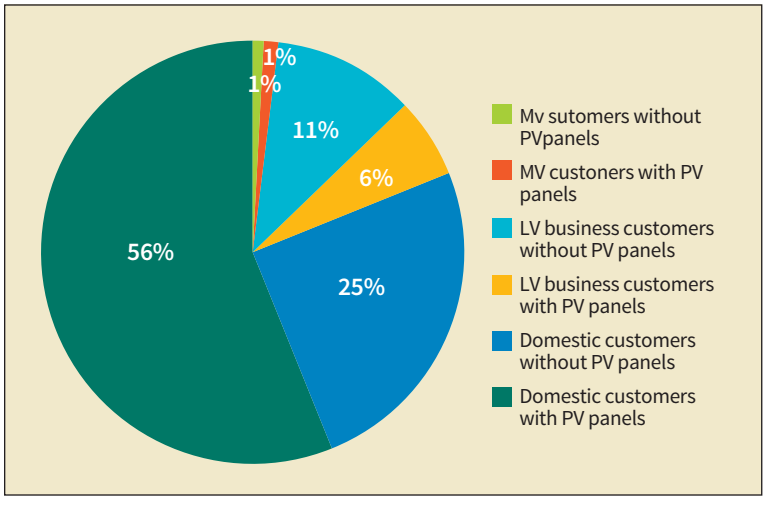
Depending on the results of the analysis, a decision is made on what corrective measure to take. A small corrective measure may include reconfiguring an existing section of the network



Trend of PQ parameters that exceed standard limit values.



Origin of PQ parameters in Enexis networks.



Distribution of PQ complaints per customer type in 2019.

or making an adjustment at the customer's installation. A larger corrective measure may require network reinforcement, such as adding an extra cable or installing an adjustable LV regulator in a feeder, to solve the voltage quality problem.

During the PQM, network impedance also is measured at the customer's POC to ensure it is reasonably low compared to the reference impedance value of 283 mΩ for the LV network, as specified in Enexis' planning guideline. The current European standard does not include sufficient information on the maximum value of network impedance for connections with different capacity installations in the LV grid.

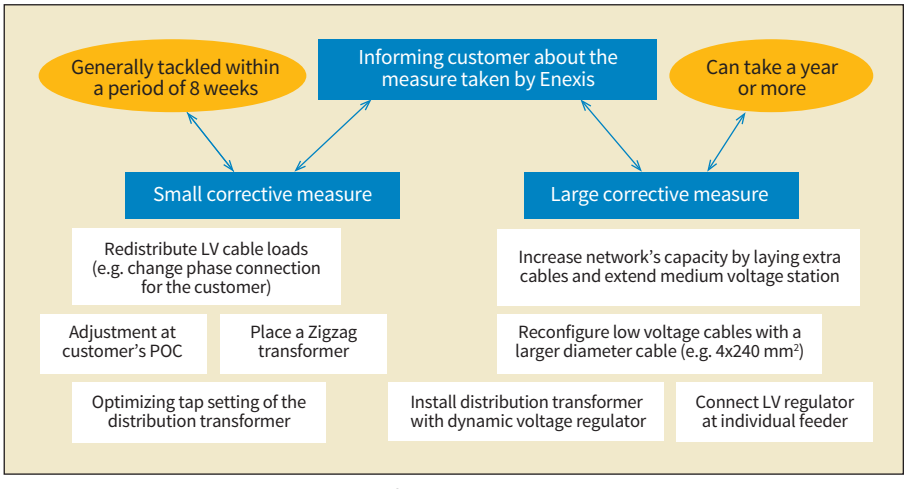
When a PQ complaint is received from a customer with rooftop PV panels, Enexis often recommends the customer first consult with the installation company, as it is often observed the customer's PV inverter setting and installation do not fully comply with the relevant standard guidelines. When a number of customers with rooftop PV installations residing in the same neighborhood complain about a specific PQ problem (for example, high voltage at their POCs), Enexis can take appropriate corrective measures at the neighborhood level by adjusting the off-load tap-setting on the MV/LV transformer in the source substation. Alternatively, a regulating transformer with a dynamic voltage regulator can be installed when all the outgoing feeders from the transformer substation have homogeneous load distributions.

The same corrective action can be applied when numerous customers opt to charge their EVs simultaneously during the peak evening hours, which results in overloading and undervoltage on the LV feeder. A smart charging approach also can be adopted for EV customers to restrict the overloading of the LV feeder and maintain the supply voltage within the standard limits.

When the outgoing LV feeders from a transformer substation are of heterogeneous type with different types of connected customers, a LV voltage regulator can be installed at an individual customer's POC or at a LV feeder terminal to solve voltage variation problems.

National PQM Program

The Dutch regulator Autoriteit Consument & Markt (ACM) requested all DSOs in the Netherlands conduct PQ monitoring on their networks to provide an improved understanding of the present voltage quality of the Dutch grids. Voltage quality parameters are monitored at all voltage levels at locations approved by the regulator. The results are published on a national website, thereby maximizing the transparency of utility services.



Various PQ mitigation measures in network.

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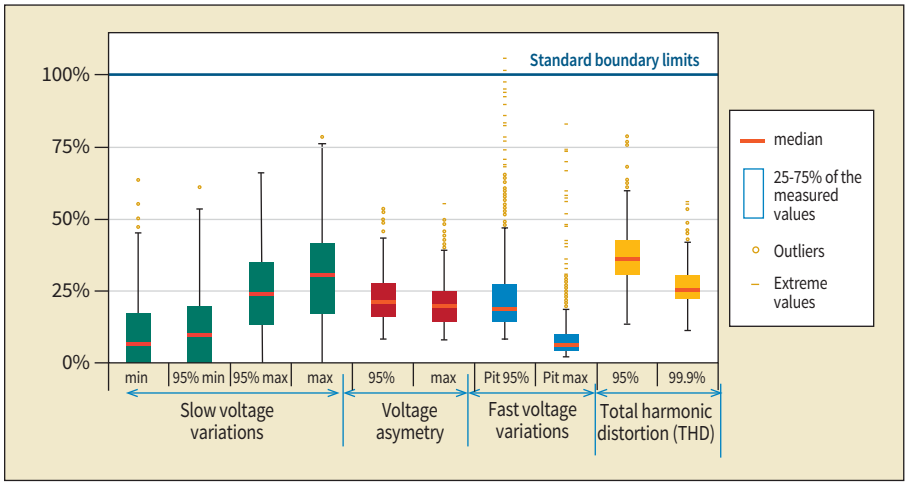

Overview of PQM results of 2019 for LV networks in the Netherlands.

Enexis conducts continuous voltage monitoring at medium-voltage (10 kV) substations. Most of the Dutch DSOs also participate in this continuous voltage monitoring program on their own networks. All these measurements help the national standardization committee to develop an appropriate and realistic standard on voltage dips that can be applied throughout the Netherlands. Furthermore, continuous monitoring is installed at all the extra-high-voltage (EHV) and HV customers' terminals and at all significant connection points on the network.

In addition, Enexis and the other DSOs in the Netherlands participate nationally in the PQM campaign to monitor their MV and LV networks, whereby 500 network points are monitored annually, each location for one week. This is conducted to access the current voltage quality status of the Dutch grids.

In the MV grids, only a few incidents of voltage parameter violations have been recorded in previous monitoring campaigns. It is mainly the LV networks where the 15th harmonic voltage values often exceed the boundary limits of the EN 50160 standard, a trend that also is common in Europe. Recently, the 15th and 21st harmonic voltage limit values for LV networks have been increased by the European Standardization Committee. Now, in accordance with the EN 50160/A3 (2019) standard, the present limit is 1% for the15th harmonic voltage and 0.75% for the 21st harmonic voltage. These stricter revisions for permitted harmonic levels will effectively reduce the number of violation incidents recorded in the national PQM reports.

Reduced Violations

Enexis has been highly proactive with PQM activities at all voltage levels on its distribution network. The results indicate 50% of the PQ complaints on its distribution network are linked to light flicker, 30% to voltage variations, and 20% to harmonics and asymmetry issues. It also is evident in recent years the number of complaints from customers with rooftop PV panels has been increasing. They sometimes experience a power outage because of the unwanted tripping of their PV inverter system, stemming from the overvoltage sensor. When many customers in the same neighborhood experience a similar PQ problem, the DSO is obliged to take the necessary corrective measures to improve customer service.

Enexis has participated in the national PQM program to monitor its networks since the program launched. Overall, the results of the national monitoring campaign confirm the voltage quality of the Dutch networks is reasonably good except for some local flicker and harmonics issues. Adaptation of the new EN 50160/A3 standard guidelines for the 15th and 21st harmonics should reduce the number of violations in the future. TDW

Sharmistha Bhattacharyya (*sharmistha.bhattacharyya@enexis.nl*) holds a Ph.D. degree in electrical engineering from Eindhoven Technical University in the Netherlands. She has several years of experience in power system consultancy and utility asset management. In 2016, she was appointed a senior consultant at Enexis Netbeheer B.V., where she employs her expertise on power quality issues in the distribution network. Bhattacharyya also is involved in various smart grid projects in the Netherlands.

ELECTRIC UTILITY OPERATIONS

NOVEMBER 2020

tdworld.com/electric-utility-operations

Rebuilding for Reliability

CONGRATULATIONS TO OUR NOVEMBER FEATURED LINEMAN!

Art Crouse

Jersey Central Power & Light

- Born in Clinton, New Jersey; raised in Nazareth, Pennsylvania; and now resides in Easton, Pennsylvania.
- Married to his wife, Jackie, and has two children, Katelyn and Bradley.
- Personal strategies for success are knowing his limitations, trying not to do too much on his own and seeking assistance when he needs it.
- Started with Jersey Central Power & Light in 1984 and became a journeyman line worker in 1997.
- Spent the last 15 years as a troubleshooter and has been with JCP&L for 36 years.
- Enjoys the outdoors, going to the beach and riding his bike and his snowmobile.

Art Crouse, troubleman for JCP&L, stands in front of his truck at the JCP&L Service Center in Morristown, New Jersey.

Early Years

I developed an interest in trucks and construction equipment and really enjoy working outdoors, all of which led to my interest in becoming a lineworker. The training for the lineworker position was challenging, and I really wasn't entirely sure I could do it, but I am so glad I chose this career path.

Safety Lesson

My number-one priority is to work safely. When you accept a job as a troubleman, you must be ready to face emergency situations, sometimes with catastrophic consequences. Working safely and taking your time to correctly diagnose the problem are always my top strategies, as well as being aware of your surroundings and never losing focus.

Life as a Troubleman

My advice to anyone interested in this field is to make sure you research the requirements and demands of the job before moving ahead. Non-traditional hours, working alone and having the confidence to determine what steps need to be taken while on your own will be your biggest challenges. Each troubleman is assigned to a specific district and each line shop has its own designated troubleman. We are assigned areas that do not require a lot of travel time to reach our destinations, which helps us get the lights back as safely and quickly as possible. When I am on my own, I like to say I am a one-person band.

Challenges and Rewards

Dealing with frustrated customers when we do experience an outage is something that you have to be ready for every day. On the other hand, once we determine the cause of the outage and safely restore power, the satisfaction and seeing the smiles on a customer's face is a feeling that can't be matched.

Memorable Moment

One time I responded to an incident involving downed wires, and I had a life-changing interaction with a resident that sticks with me to this day. After safely positioning my truck in a secure location and waiting for tree and crew line assistance, a local approached my truck and appeared to be not so happy. Part of my job is to interact with frustrated customers, so I engaged in conversation. After a while, we began to talk about our mutual interest in auto racing and how we loved Mario Andretti, who hailed from Nazareth, Pennsylvania, which just happened to be our hometown. I so enjoyed our conversation that I went out of my way to share with him some of my auto racing magazines. Well, years passed, and to my surprise, this customer reached out to me to let me know that he had suffered a stroke and that having my auto racing magazines to read led to his recovery. We remained friends until his passing. To this day, I still get emotional thinking about this incident and how you never know how your interactions with customers can impact their lives. TDW

Editor's Note: *T&D World* is excited to partner with Milwaukee Tool on a new sponsorship for the linemen profiled in our Lifeline department. To thank the linemen for their dedication to the line trade, Milwaukee will send a special custom tool package to each lineman profiled. To learn more, visit *www.tdworld.com/electric-utility-operations*.

If you are interested in being profiled in our monthly Lifeline department or know of a journeyman lineman who would be a good candidate, email *T&D World* Field Editor Amy Fischbach at amyfischbach@gmail.com.

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Field Applications

Lineman Invents New Stringing Block for Industry

The patented CRS Block will help workers to stay safer in the field and improve productivity.

By **Amy Fischbach**, Field Editor

Robert Seekell, a 20-year power lineman, OSHA outreach trainer and T&D instructor, has a passion for training to make the line trade safer. Rob is a member of Local 659 and resident of Boise, Idaho, worked at Northwest Lineman College for five years and traveled around the US to work as a lineman.

Robert Seekell says his wife, Alison, has helped him on his 7-year journey to invent a new product for the line trade.

For decades, he has strived to make the line trade more efficient. To help linemen to save time and improve their safety in the field, he has invented a new stringing block design for the power industry.

Called the Condux Radius Safety (CRS) Block, the nonconductive stringing block has two patents on the base and top sections. Seekell designed the block to use advanced new technologies and materials linemen are starting to use today in the field.

By partnering with Condux International, a Mankato, Minnesota-based company, Seekell is leveraging the company's manufacturing expertise to transform the concept into reality. Condux is currently in the final stages of development creating the CRS Block with a patented base and block body. The outer body is high vis in color, and all the conductive pieces are covered with a nonconductive coating. The company plans to launch the 20.2-in. version and a 10-in. model initially with larger sizes available in the future.

"This is going to be the first radius block in different sizes that will mount to the utility crossarms, attach to a pole or can hang," Seekell said. "The block will not only be safer, but also be faster to install."

Saving Time in the Field

The average install time on a block used today in the field is one to two minutes, and the CRS Block is said to take only 12 seconds to install. Due to its ratchet strap design, the CRS Block allows linemen to use their 3/4 rattle gun to speed up the installation. The design of the base can also adjust to five different angles with the pull of a pin, and the conductor never has to be removed to change the angle like the old X100 blocks. This step alone made it a safer block, Seekell says. When mounted on the arm the new block can pivot completely upside down for upstrains.

To make the CRS Block even lighter, the base can be removed when in a hanging application. Other 20-in. diameter blocks weigh around 45 to 55 LBSs., but the 20-inch CRS Block weighs 25 lbs. without the base. The base will also allow the old X 100 blocks to drop into the base so the linemen can use the new features of the base to add efficiency to the old block. The block can be used on all types of conductors and fiber to mitigate about any angle needed for a stringing project.

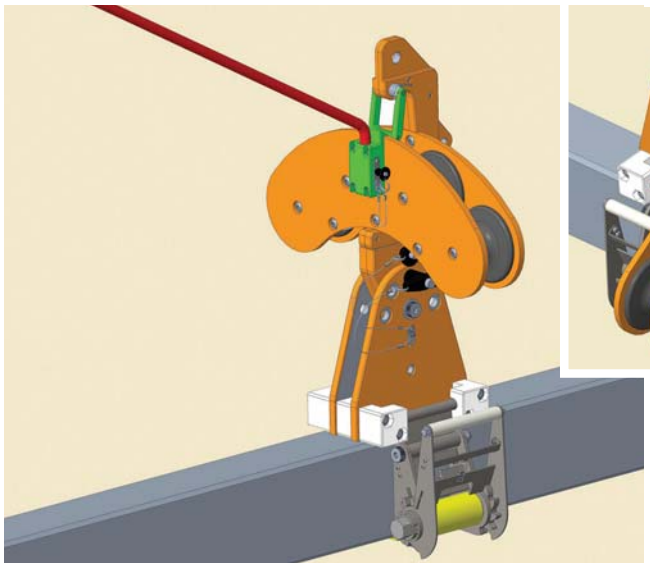
"There has never been a stringing block in the industry with so many safety features to improve safety and help to advance the electrical circuits," Seekell says. "I felt I nailed it when I made a block that was not only safer, lighter but faster for our trade. This is a tool made for linemen by a lineman."

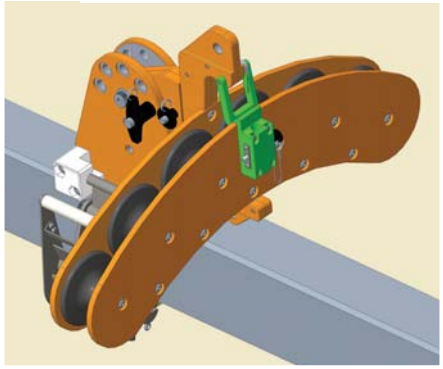
Installing Tree Wire and New Age Carbon Core Conductors

Linemen can also use the CRS Block to install new age carbon core conductors or insulated tree wire, which needs a larger radius stringing block so installers don't damage core or insulation.

With insulated tree wire applications today, some companies have been de-energizing the power line to pull in the insulated tree wire because they need the larger diameter radius for stringing the tree wire, and the blocks they are using only hang under the arm.

"If they had the CRS Block, it would mitigate the issue and make the job safer, faster and keep the lights on," Seekell says.





These drawings show a prototype of the CRS Block designed by Lineman Robert Seekell and produced by Condux International.

Assisting Drone Stringing Operations

As the CRS Block is introduced into the marketplace, Seekell envisions it also being used as a tool for drone stringing operations. The top has a spring-loaded inward opening gate to trap the pull line or conductor to make wire stringing jobs in the United States safer and faster. The new design has a non-conductive removeable guide arm to assist the drone when stringing.

"With drone technology improving, we are going to see more drone use in the power industry," Seekell said.

Seekell has reached out to many drone companies to understand their challenges in the field to build a block that will help mitigate any issues they are facing.

"Linemen are going to be working more and more energized circuits because it is harder to deenergize the customers," he said. "With all the safety and efficiency that was built into my block, this will make our trade safer and help take care of the growing need to improve our grid."

Seekell said he feels he has been blessed to have the opportunity to work in such a great trade and work side by side with some of the greatest lineman and industry professionals who helped him with his skill set and experience gained. He wanted to thank his friends, pole buddies and family that has helped in the development of the new CRS block and base. In the future, he plans to introduce more tools to improve linemen's safety and efficiency. TDW

Three Phase Line crews maneuver equipment situated atop timber mats into position to pull new wire and attach it to new steel transmission structures.

Linemen Rebuild Line to Ramp Up Reliability

A transmission rebuild job is underway in central New York to reduce outages in National Grid's service territory.

By **Peter Rivizzigno**, Three Phase Line Construction

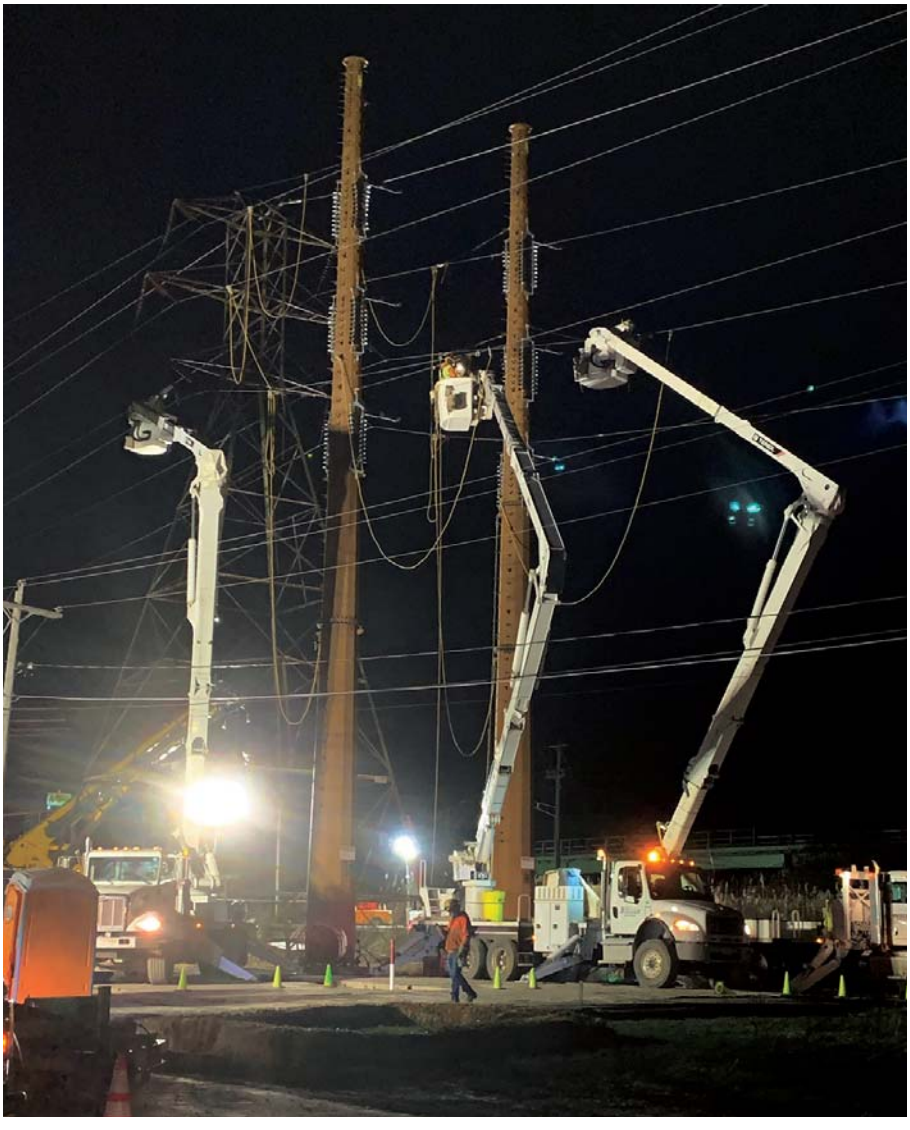
Linemen have been swapping out older wood structures and conductors with modern equipment on a transmission rebuild project in New York State. The new lines traverse 25 circuit miles including wetlands regulated by the New York State Department of Conservation and the federal government, as well as three interstate highways, one state highway and one railroad.

National Grid owns and operates electric transmission lines within existing rights of way (ROW) in Central New York. As the contractor for National Grid, Three Phase Line Construction Inc. is rebuilding the existing Clay-DeWitt Line 3 and Clay-Teall Line 10 115 kV transmission lines, which cross through the Towns of Clay, Cicero, DeWitt, and Salina in Onondaga County, New York.

As part of its scope of work, Rochester, New Hampshire-based Three Phase Line Construction is replacing existing

conductors on these two lines with new higher capacity conductors, modifying or replacing a majority of the pole structures associated with the lines, relocating a portion of the lines to the center of the ROW and other portions to a different ROW corridor. Workers are also wrecking out about four miles of existing double-circuit line.

The project, which is the largest of its kind that Three Phase Line Construction has taken on as a company, began in August 2019 and is scheduled to wrap up in 2021. Upon completion, the transmission lines will be less susceptible to outages caused by infrastructure failure, and National Grid will offer improved power reliability for businesses and the local economy. According to National Grid, the transmission rebuild project will lessen the dependence on localized electrical generating facilities and promote greater electrical generation diversity like renewables.



Working through the night to minimize disruption across a state highway crossing, Three Phase Line crews transfer a conductor from an old structure (in the background, to a new one in the foreground).

Overcoming Environmental Challenges

For Three Phase Line Construction, the transmission rebuild project is different from other jobs due to its size and environmental challenges. Because the job has been designated as an Article VII project, the New York State Public Service Law sets forth a process to review the need for, and environmental impact of, the siting, design, construction and operation of certain major electric and gas transmission facilities.

Because portions of this line fall within wetlands and sensitive environmental areas, the crews have to strictly follow the Environmental Management and Construction Plan (EM&CP), which was prepared by National Grid and approved by the DPS during the Article VII review process. Three Phase Line Construction always focuses on strictly adhering to environmental regulations and processes during construction. For example, National Grid's surveyors meticulously map project limits of disturbance and delineate them in the field. All construction-related activity must remain within those limits with no exceptions. Even a single tire track left outside the limits of disturbance could result in a notice of non-compliance with the permit.

Since the company is performing a lot of its work in wetlands, its crews have had to put in place roughly 30,000 timber mats, which create temporary work platforms, roadways and staging areas. By comparison, the last environmentally sensitive (Article VII) project Three Phase Line Construction worked on required the use of 18,000 timber mats.

The number of mats is a function of how much of the project is in wetlands or agricultural land. In some instances, adhering to environmental controls means larger segments of protected area have to be matted. The work involves building a timber mat road and then building a timber mat pad around a structure to drill a foundation, install the structure and then clip in the new conductor. The drillers tend to go faster than the line crews, so Three Phase Line Construction must leave enough mats behind to allow for the line work.

When working with mats, a contractor must be flexible and adapt to changes once the work gets started. The plan might call for building a timber mat road with a 90-degree turn. In the field, however, crews may discover that if they do that, they couldn't get a 100-ft bucket truck through the turn without

encroaching on the wetland. If this happens with the Clay-DeWitt Line 3 or Clay-Teall Line projects, then Three Phase Line Construction would suggest changes to National Grid, which would amend the plan and submit it to New York State for approval.

By accounting for turnaround time for approvals like the kind mentioned above, Three Phase Line Construction keeps its crews from getting off schedule. Because Three Phase Line Construction has experience with Article VII projects, it knows how to keep work moving in other areas and stay on track and budget, while accounting for changes. Right now, Three Phase Line Construction is working through a change involving converting temporary gravel roads into permanent, permeable paver roads.

Three Phase Line crews use a mobile telescoping crane to assist in connecting a new Cor-Ten steel transmission tower near Cicero, New York, for National Grid.

Getting the Job Done on Schedule

About 70 workers from Three Phase Line Construction and its subcontractors worked on the project at the peak of construction, and since that time, about 60 workers are still on site to finish the project. The crews are rebuilding the line with modern COR-TEN steel structures and 1113 aluminum conductor steel reinforced (ACSR) cable and tying the lines into existing substations. These lines will replace 4/O copper conductor on wood pole H-frames and steel flex towers.

The linemen are installing 184 new structures like steel monopoles, H-frames and three-pole deadends and new wooden poles. Most of these structures will be supported by the 150 new drilled pier concrete foundations with the rest being direct-embed structures. The average depth and diameter of the foundations is 30 ft deep and 8 ft wide. The project also calls for 31,000 ft of permanent gravel access road.

To keep the large transmission project on track, it takes careful and thorough planning including the coordinated scheduling of outages. With two circuits feeding four different substations, this has to happen flawlessly to keep work progressing on various parts of the line with no delays.

To progress toward the finish line, Three Phase Line Construction is focusing on good field leadership, building dedicated and experienced crews and providing them with the tools and equipment they need to do their work safely and efficiently.

As of late summer, the team is ahead of schedule on the project because its superintendent and general foreman are looking two or three weeks ahead for anything that might cause a delay. Through advance planning, they might notice that an access road has a turn that's too sharp for a bucket truck to maneuver or that matted work pad is not big enough to accommodate the equipment needed to do the work. Through a focus on organization and preparation, Three Phase Line Construction is helping National Grid modernize its transmission system and boost power reliability in the region. TDW

Peter Rivizzigno (*peter.rivizzigno@3phaseline.com*) is a senior project manager for minority-controlled business Three Phase Line Construction Inc. where he is responsible for managing the company's transmission projects across the Northeast. He received his bachelor's degree in geology from Miami University and master's in geology from Duke University.

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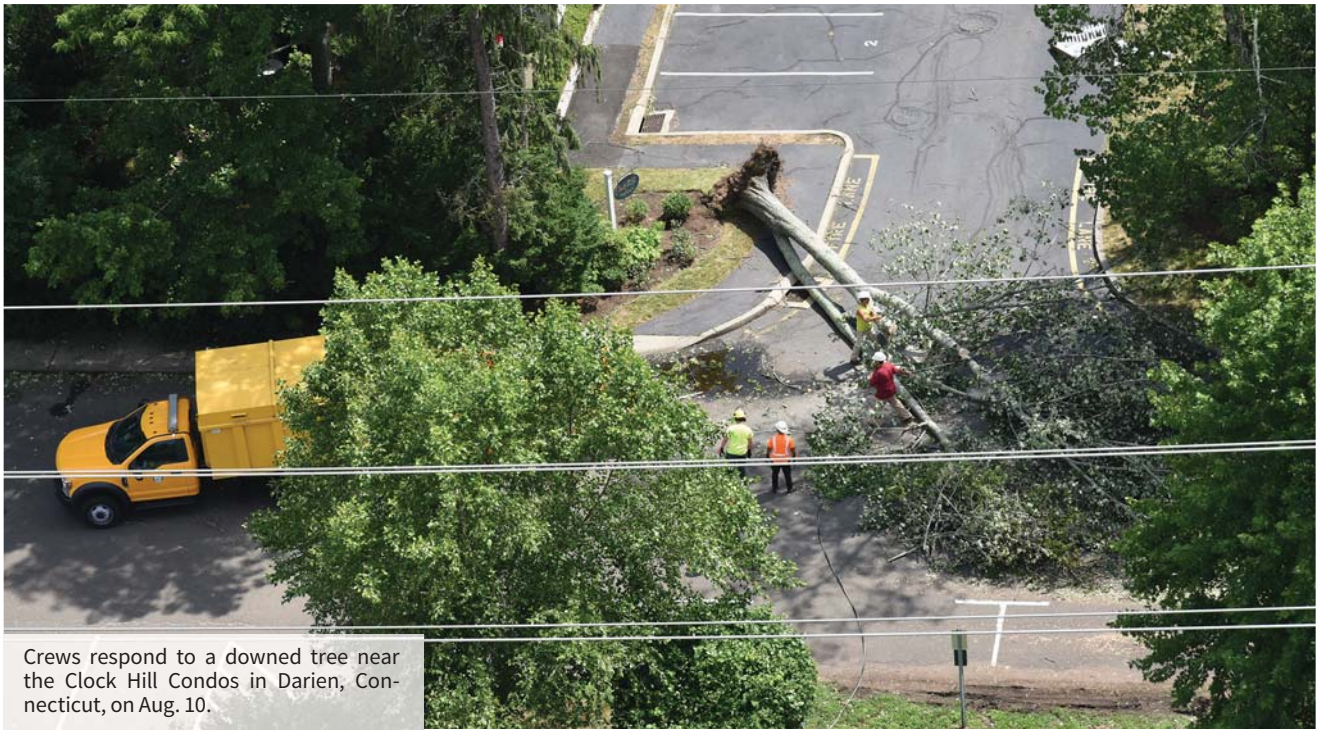

Crews respond to a downed tree near the Clock Hill Condos in Darien, Connecticut, on Aug. 10.

Linemen Rebuild Grid Following Tropical Storm

After Isaias hit Connecticut, Eversource partnered with mutual assistance crews to restore power in record time.

By **Amy Fischbach**, Field Editor

Tropical Storm Isaias packed a punch in Connecticut, inflicting widespread and severe damage greater than both Super Storm Sandy and Tropical Storm Irene. All 149 communities served by Eversource in Connecticut sustained some degree of damage to their electrical system. In some cases, the damage was so severe that parts of the grid had to be rebuilt.

After the storm roared through the state, Eversource used drones to quickly assess damage in hard-to-reach areas where 2,000 roads were blocked. The line crews then responded to 2,500 broken poles, 1,100 damaged transformers, 10,000 trees and more than 500 miles of downed or damaged lines.

The windward side of Tropical Storm Isaias tracked over Connecticut, which brought the heaviest winds and damage of the three storms. The tracks of Storms Sandy and Irene had heavier rains, resulting in more flooding. Despite the high level of damage to its system, Eversource was able to restore Connecticut customers in record time. While Tropical Storm Isaias resulted in more damage locations than Sandy and Irene, the line crews restored power following Isaias in eight days, Sandy in 11 days and Irene in 12 days.

"We achieved our initial goal — to have 90% of our customers in power — ahead of schedule," said President of Regional Electric Operations Craig Hallstrom. 'The thousands of crews that worked tirelessly on this massive restoration mounted a heroic effort and did a tremendous job under difficult conditions — working in the heat while abiding by strict social distancing and pandemic safety protocols — all while restoring customers in record time."

Being Prepared

To respond quickly to the storm damage and to outages, Eversource's Incident Management Team activated its Emergency Response Plan well in advance of the event. The team

Downed tree branches, electric lines and equipment are scattered across Route 10 in Southington, Connecticut, on Aug. 5.

was thoroughly prepared for a major event with greater impact than models predicted.

Three conditions combined to intensify the destructive force of the storm beyond expectations. First of all, the westerly track of the storm toward the New York border left Connecticut on the east side of the storm where the higher impact winds occurred. This condition was forecasted on Monday, Aug. 3, but would not have unexpectedly elevated the destructive force of the event on its own.

Secondly, as the storm was dissipating, it spewed higher sustained winds and wind gusts than anticipated across a widespread area, with localized pockets of powerful winds that caused severe impact to trees and vegetation surrounding the overhead system.

Finally, long-running drought conditions occurred across Connecticut in 2015-2017, undermining the integrity of tree root systems and making trees more vulnerable to insect pests and diseases. The higher-than forecasted sustained wind speeds in local circulations caused thousands of mature trees with full leaf canopies to topple on to overhead electric infrastructure.

Eversource line crews work to make repairs following Isaias on Aug. 8 near Route 80 East in Madison, Connecticut.

Focus on Vegetation Management

A perfect storm of weather conditions and insect infestation over the last several years devastated Eversource's trees across Connecticut. The state experienced significant winds in a short period during a season when those trees are in full leaf canopy, which resulted in extensive damage.

Mature trees weakened by drought, disease and insect infestation brought down wires and poles in every corner of the state, significantly damaging the electric system to the point that portions of the grid had to be rebuilt.

To address the damage arborists dispatched more than 750 tree personnel, some were paired up with electric line crews to handle complex trouble spots, other tree crews were dispatched to clear the way in advance of line crews to help speed the restoration effort. Arborists dispatched these crews based on information drawn from the energy company's Outage Management System.

Expediting Restoration

Peak outages as a result of Tropical Storm Isaias occurred at 3:30 p.m. on Wednesday, Aug. 5, 2020, and impacted 632,632 customers. The southwest corner of the state and the Hartford region were the hardest-hit areas, yet damage from this storm was experienced in each town in Eversource's service territory.

As the line crews worked to replace damaged poles and pole-top equipment like cross arms and hardware, they rebuilt the infrastructure to the company's most updated standards. For example, they replaced broken wood crossarms with stronger, composite cross arms.

To speed up the restoration of power, Eversource deployed decentralized satellite command centers to six locations across the state, where experienced operations leaders drove and controlled the restoration process in their area. These satellite command centers put the crews and materials closer to the areas where they were needed most, providing greater flexibility to more quickly deploy the massive crew resources. This localized approach also reduced communications and materials bottlenecks and provided more efficient deployment of crews to expedite the progress.

The new mobile command centers give the operations personnel the same capabilities they would have sitting in an Eversource facility. The mobile command center allows for full integration with the company's suite of restoration tools, such as the Outage Management System, Vehicle Locating applications (AVLS), and Microsoft applications such as Teams, etc. It allows the company to push the restoration activities out into the field to be closer to the work with no degradation of capability.

Eversource line crews work to make repairs on Aug. 7 following Isaias in Old Lyme, Connecticut.

Staying Safe

Eversource has been operating under its COVID-19 pandemic plan since Mid-March, and those guidelines were reinforced with crews working to restore power for their customers. For example, everyone working on the restoration effort wore face masks, practiced social distancing and followed strict sanitation requirements.

In addition, staffing at seven mobile command centers around the state was limited to half the capacity at each location. The support staff overseeing the logistics including meals, lodging and fuel continued to work remotely.

Eversource crews work to restore power in Amherst, New Hampshire, on Aug. 6 following Isaias.

Thousands of line and tree crews from across the country and Canada worked day and night throughout Connecticut to restore power. Thousands more personnel coordinated the effort behind the scenes, from orchestrating the flow of thousands of new utility poles and transformers to the devastated areas, to securing more than 6,500 beds for crews and serving more than 30,000 meals daily. To safely accommodate crews repairing the storm damage, Eversource established staging areas across the state while adhering to the energy company's pandemic protocols to safeguard the health of its team and communities.

Lodging accommodations were used at about half their capacity to maintain social distancing, and the number of team members working in mobile command centers was also limited to about half-seating capacity.

The Safety Department also adjusted its onboarding process to ensure workers' health. Contractors were provided all of their onboarding instructions with video messages rather than in large, group meetings. Additionally, thousands of supporting team members, from customer service representatives to damage assessment coordinators, worked remotely.

Through a focus on safe and efficient restoration, Eversource was able to get the lights back on in all the affected towns throughout Connecticut.

"Isaias is one for the record books," said Hallstrom. "Connecticut was hit the hardest of any state in our region, and we organized an outstanding response to support our customers. We also understand how difficult this storm was for our customers, especially given the pandemic and the other challenges that 2020 has brought." TDW

Products & Services

Battery-Heated Shirt

The Heated WORKSKIN Midweight Base Layer by Milwaukee Tool is powered by its REDLITHIUM USB Battery Technology with carbon fiber heating elements to create and distribute heat to the chest and back. A one-touch LED controller allows users to select from two heat settings, delivering heat for any environment. The Quick-Heat function allows users to feel heat three times faster in the chest and upper back heating zones. Combining a double-lined polyester body and fleece-lined arms, the Heated MILWAUKEE WORKSKIN Midweight Base Layer provides a versatile layering piece for total body warmth. This battery-heated shirt features raglan sleeves and seamless shoulders for an improved range of motion and comfort while working. This heated base layer kit includes: one Heated WORKSKIN Midweight Base Layer, one RLUSB 3.0Ah Battery, one REDLITHIUM USB Battery Controller/Charger, and one 3 ft Micro-USB Cable and 2.1A Wall Charger.

Milwaukee Tool | www.milwaukeetool.com

Safety Helmet Visor

Klein Tools introduces two new additions to its line of personal protective equipment: tinted and clear safety helmet visors. They are designed to add eye protection to Klein Tools' safety helmet while still maintaining a low profile. They provide impact protection and are tested to the latest latest ANSI Z87.1+ (2020), CSA Z94.3-20 and MIL-PRF-32432A (Class 1-ballistics fragmentation) standards. They also feature an optical Class 1 lens, tinted or clear, tested for minimal distortion to ensure uncompromised vision across entire surface. The visors have a low profile and feature a half-face, wrap around design to match and maintain low profile design of Klein Safety Helmets. The anti-fog coating will not wear off, and it even works with dust masks. They are scratch resistant and feature a specifically treated lens for added durability to survive demanding job sites. UV protection: tested to ANSI Z87.1 U6 standard, effectively blocking 99.9% harmful UV-A, UV-B and UV-C rays. They are designed with lightweight materials and vents to maintain adequate ventilation, and it locks in up and down positions to maintain desired position when moving the head.

Klein Tools | www.kleintools.com

Field App

Clearion Software released its next-generation field software for all field workers to build and manage detailed work plans and seamlessly communicate with crews. The software also extends data creation tools to contractor crews and field supervisors to enable new use cases for Clearion customers. Like the earlier release of Clearion Crew, the new product is supported across all mobile platforms with a fast and easy app-store deployment for iOS, Android, and Windows. With this latest release, Clearion now offers a single cross-platform application for all field worker roles. To provide the wide range of data access and data management tools needed to support complex construction and maintenance workflows, the app automatically changes based on easily administered user roles. The new app delivers geospatial data creation tools, intelligent forms, a data automation engine and other user-centric features that ensure inspections, work planning, and auditing are fast and accurate. The new Clearion field app seamlessly integrates with the Clearion work management module and leverages the latest enterprise technology from Esri — ArcGIS Online and ArcGIS Enterprise with their respective Portal environments. Clearion allows both online and offline modes with on-demand local data storage that can be controlled by the end user, eliminating the time-consuming step of deploying large background data files to all users or the need for labor-intensive back office processes. The app also features a fully re-designed sync technology for offline users and introduces real-time server communication for planners and auditors when mobile connectivity is available.

Clearion | www.clearion

Walkie-Talkie Rugged Smartphone

The Atom XL is a an upgraded version to the small 4G rugged smart phone, Atom, which was launched in the 2018 Kickstarter campaign. Compared to former Atom, Atom XL has better performance over the camera, battery power, convenience and security. The Android 10 phone features a 48 MP camera, 4-inch screen, DMR walkie-talkie and is waterproof, dustproof, shockproof and fast charging.

Unihertz | https://www.unihertz.com/ TDW

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Parting Shot

Photo by **Josh Monteith**

Vasily Bogdonoff, a graduate in Northwest Lineman College's Electrical Lineworker Program, frames a dead-end during his class rodeo on the Idaho campus in March 2020. He included a smoke bomb in his tool belt for fun and motivation for the timed team event.

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Discovery and Innovation with Machine Learning

Program uses artificial intelligence to predict utility asset failures and prevent outages.

By **Tom Bialek**, San Diego Gas & Electric Co., and **Gregg Edeson**, PA Consulting

Now more than 100 years old, the U.S. electrical grid is showing its age. In fact, 70% of transmission and distribution lines are more than 25 years old, according to the Department of Energy. Utility systems historically have been installed underground in high-density urban and suburban areas to preserve aesthetics and increase system longevity and safety. On the downside, undergrounding has made it more difficult to locate, access and repair failures in these densely populated areas.

San Diego Gas & Electric Co. was faced with this situation. Making up more than 60% of its total distribution grid, the utility's underground assets are now approaching more than 40 years in age. In the last 10 years, T-splices were responsible for more than one-third of all increases in the utility's asset failures. SDG&E manages more than 10,500 miles (16,900 km) of underground distribution lines and an estimated 150,000 T-splices on 700 underground circuits. The utility needed a better way to predict which of these assets would fail next.

Simple electrical components that join mainline underground cables, T-splices are like other assets in that they can fail routinely, causing unplanned outages. It can be hard to locate the outages immediately because T-splices are underground and not directly monitored by the control center, as they are considered minor assets. In an era of digital transformation, it may seem astonishing an electrical part costing less than US$60 can trigger outages that impact customers' daily lives and cause utilities tens of thousands of dollars to resolve.

To fix this issue, SDG&E set out to create a solution for identifying high-risk T-splices prior to failure. The utility partnered with PA Consulting and Toumetis, a predictive analytics provider for the industrial internet of things, to develop a machine learning (ML) solution that could predict asset failures with not only a high level of accuracy but also sufficient warning. The eventual solution, called iPredict, was introduced recently to the market by PA Consulting for other utilities and extends to asset classes beyond T-splices.

T-splices, the initial asset class studied by the SDG&E and PA Consulting teams

A Deeper Look At Data

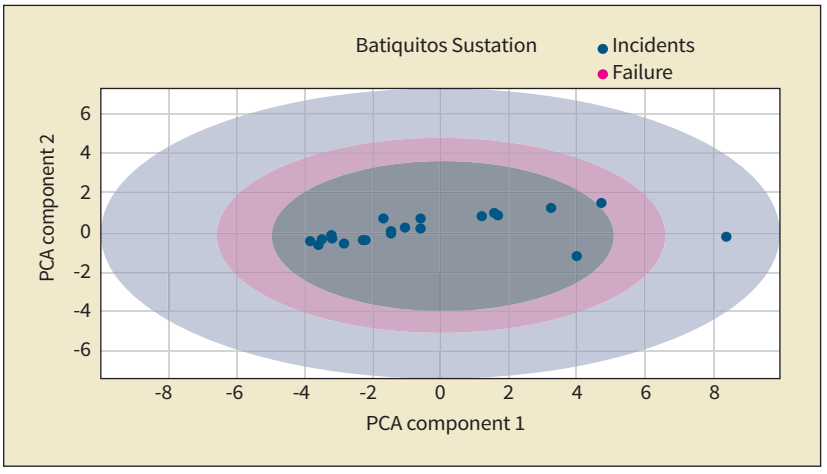
Data is at the heart of all utilities. However, comprehensive integration of operational data sets — for example, from the outage management system (OMS), supervisory control and data acquisition (SCADA) system and geographic information system (GIS) — is not easy to put in place. Although standard information technology/operational technology (IT/OT) data integration of these systems' connectivity data can be challenging and complex, such integration is becoming more common. This comprehensive integration can be helpful for use cases such as identifying outage causes, diagnosing unhealthy assets and setting up alarms for operational staff to analyze.

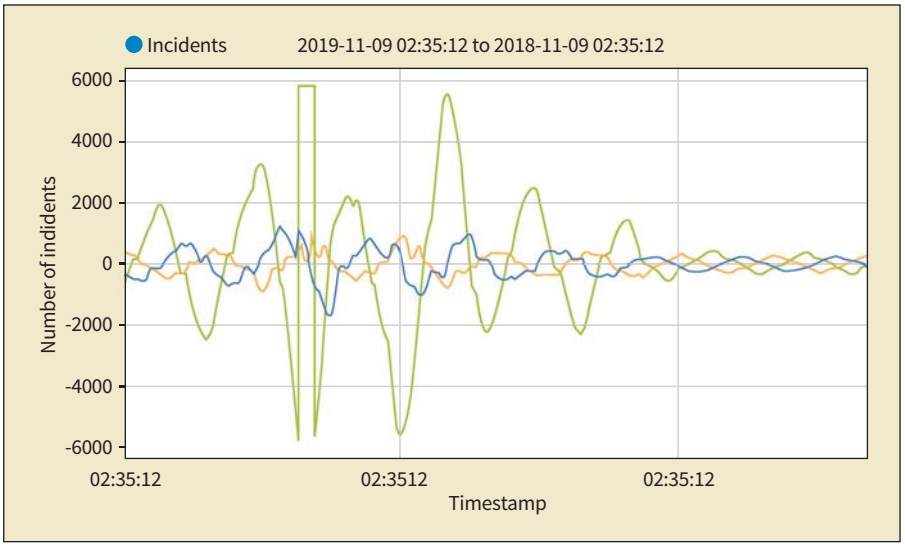
It is much more difficult and less common to integrate system performance operational data with power quality data, from the same sources noted pre-

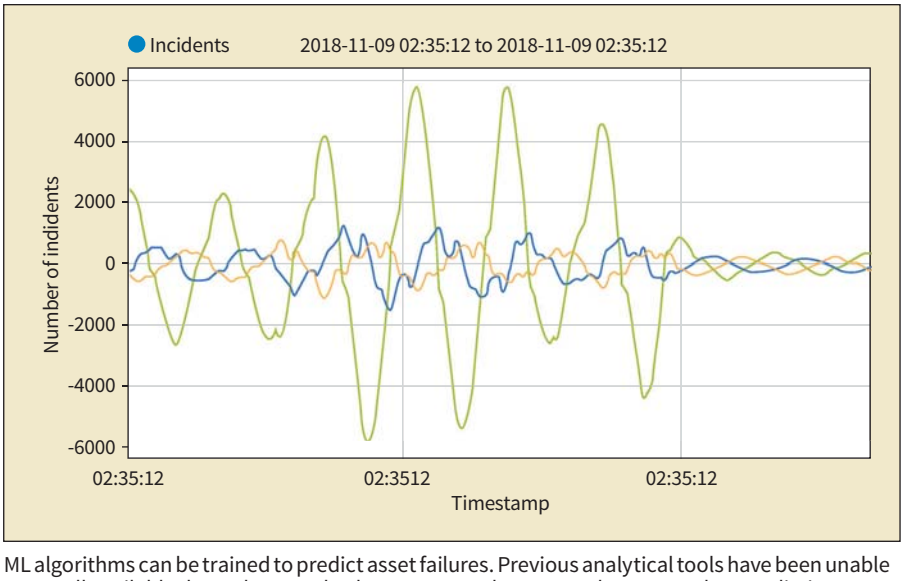
viously, including OMS, GIS and SCADA, as well as relay and protection systems. However, this data can be used for much more granular analysis of assets to provide improved predictive insights.

The project team found this more granular, high-frequency data needed to be correlated with other system data for the algorithms to predict T-splice failures with high confidence. To identify critical asset faults, algorithms needed to recognize and interpret anomalies that last less than two 60-Hz voltage and current waveform cycles. These data portray the spectrum of normal cycles versus those that indicate incipient/precursor signals, a predictive signature of asset failure.

The project team discovered the accuracy of asset failure predictions could be increased by using sub-cycle data — available from sources such as power quality (PQ) meters — to identify the fault anomalies and resulting predictive electrical signatures. In SDG&E's case, these data previously had not been analyzed beyond voltage monitoring and regulation. This was a pivotal discovery on the journey to identify essential data in populating ML algorithms for predicting T-splice failure. It was a case of discovering previously unleveraged data that had not been integrated with the standard set of utility IT/OT data sources.







ML algorithms can be trained to predict asset failures. Previous analytical tools have been unable to use all available data. They need at least two steady-state cycles to pass, but predicting asset failures requires the system to interpret more transient anomalies. ML algorithms sift through and analyze all available data, identifying potential faults where other techniques have failed.

High-Sample Rate Data

The PQ meters at SDG&E's substation bus level provide data at a high sampling rate of 128 samples per 60-Hz cycle, which enabled the ML algorithm to develop fault signatures that could help to predict end-of-life asset failures. The project team spent about 18 months aggregating, cataloging and integrating the high-sample rate data to prepare it for use in the algorithm. Learnings from this journey of discovery have resulted in identifying previously untapped data, integrating it with other data sources, and discovering the power and strength of ML applied to utility engineering, asset management analytics and operations.

Developing and training the algorithm required a high degree of utility engineering and operations subject matter expertise. This synergy of data science and deep knowledge of engineering principles and asset behavior enabled the code to be cracked, so to speak, for the ML solution.

These photos are illustrative samples of T-splice failures in the underground electrical system throughout the United States.

To categorize assets as either normal or indicative of a forthcoming asset failure, the team had to correlate the circuits' PQ data with outage data to gather enough of the desired data (fault/incident versus normal conditions) and then coordinate time stamps between the OMS reports and high-sample rate data. It was a classic reverse-engineering scenario where the data was used to create the desired waveform signatures for the failure as well as the signatures leading up to the failure. The algorithm was trained with this data to recognize the waveforms.

In addition, the team sought to leverage existing installed hardware, such as the PQ meter — rather than simply purchasing new hardware alternatives — to reduce the overall cost of the solution. The team also considered additional data samples and asset failure incidents to determine whether they could be exploited to enable the program to predict other types of asset failures.

Identification of high-frequency failure data for more asset types has resulted in the creation of additional algorithms (yet to be fine-tuned) for several other critical assets, such as oil switches, load break elbows and transformers. These algorithms will provide predictive insights and enable SDG&E to identify other types of critical asset outages. The processing of additional high-frequency sub-cycles and cataloguing of predictive signatures matched to asset failures will expand the ability to identify and predict additional asset failures.

Extending The Analytics

SDG&E is seeing success with how this ML solution can integrate and analyze data from multiple sources as well as identify asset locations more definitively. PA Consulting is looking to bring the iPredict solution to other U.S. utilities.

Applying the discoveries of this team, utilities can develop more robust data integration architecture solutions to increase their overall visibility of specific asset health. The solution can help utilities to identify probable failures of cables, elbows, overhead and underground splices, and junctions weeks in advance.

Other utilities can build on SDG&E's process by identifying the right data sources required by the algorithms as well as streamlining the data collection and integration process. This innovation can empower crews to identify near-term asset failures and schedule repairs at the best time to minimize customer impact, maximize public and employee safety, and reduce environmental harm. TDW

Tom Bialek (*TBialek@sdge.com*) is the chief engineer at San Diego Gas & Electric Co. (SDG&E), where his responsibilities involve technology strategy and policy for transmission and distribution issues, including equipment, operations, planning, distributed generation and development of new technologies. Over the past four decades, Bialek has held various positions with other North American utilities and equipment manufacturers. His experience includes electric utility design, planning and operation as well as equipment design, development and manufacturing. He is leading SDG&E's technical analysis supporting the iPredict effort. Bialek currently serves on the U.S. Department of Energy's Electricity Advisory Committee as vice chair of the smart grid subcommittee. He also chairs the National Renewable Energy Laboratory's electric system integration technical review panel.

Gregg Edeson (*Gregg.Edeson@paconsulting.com*) is the reliability lead at PA Consulting. A recognized leader with more than 40 years of experience in the electric utility industry, Edeson helps clients to excel with grid modernization, asset management and reliability improvement strategies as well as drive organizational value from IT and OT investments. He works with utility executives to implement operational improvement initiatives using digital transformation, artificial intelligence and machine learning to fuel continuous innovation. Edeson also serves as program director of ReliabilityOne, widely recognized as one of the electric utility industry's most prestigious honors. PA's ReliabilityOne awards recognize electric utilities for providing customers with the highest levels of reliability in the industry.

For more information:

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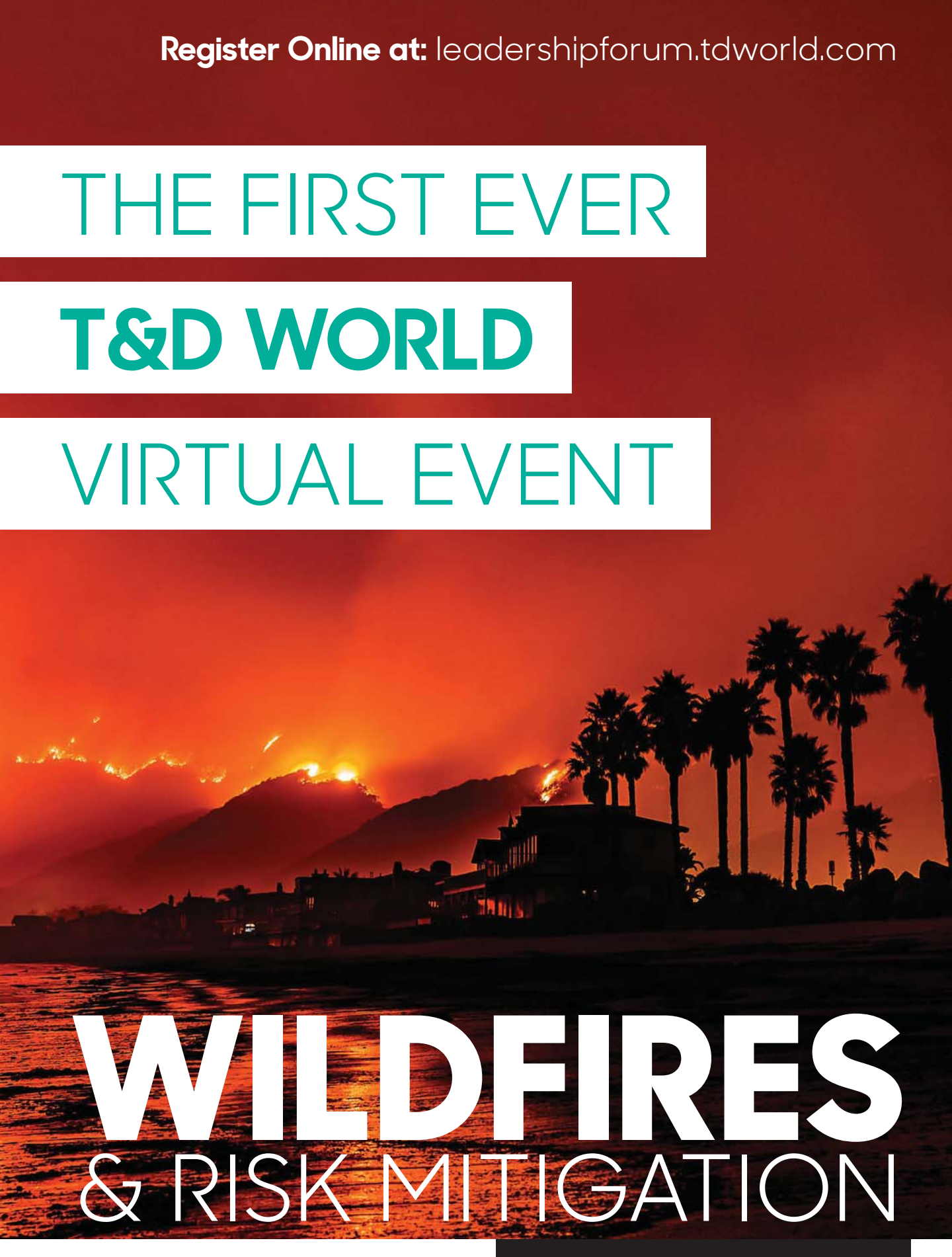

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Energy Storage System

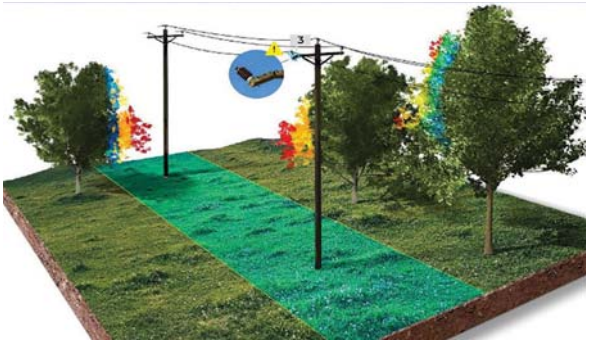
The Wärtsilä GridSolv Quantum solution is a fully integrated modular and compact energy storage system. It is a pre-engineered and validated package with matrix site layout, designed for ease of deployment and sustainable energy optimisation for various project locations and market applications. Designed for flexibility and functionality, it is a complete solution that includes different sub systems — thermal management, safety and enclosure — that work together to deliver maximum safety at the lowest lifecycle cost. A key design feature includes UL9540A limiting 2-hour battery firewall envelope testing that ensures an improved NFPA 855 fire safety compliant site. The solution is compliant with all applicable North American and international standards.

GridSolv Quantum can host up to four liquid-cooled racks per enclosure, which can be linked together to form a complete system. The solution can be installed as a single enclosure, or as a system of several parallel enclosures, enabling the most optimal configuration to meet project requirements. It is fitted with a number of safety features such as UL9540A-tested lithium iron phosphate (LFP) batteries, a 60-minute enclosure fire rating, fire detection and a selection of fire suppression methods, plus pressure relief panels on the roof. GridSolv Quantum is designed to meet international safety standards. It is designed with individual rack-based cooling circuits, careful equipment selection and high seismic capabilities, catering for a long lifespan in all conditions with minimum service interventions. It also features include the ability to withstand wind, a high ingress protection design, and a long duration surface treatment specification.

Wärtsilä | www.wartsila.com

Visual Intelligence Platform

GE Digital has introduced a purpose-built Visual Intelligence Platform for utilities. The SaaS solution is designed to ingest all forms of visual inspection data and executes workflows and automated analysis that contextualizes data into Digital Twins of the network and environment. The Digital Twin generates business intelligence that is consumable, shareable, and actionable to drive an expected 27% cost savings versus current practices. European DSO, Enedis, wanted to reduce the cost of helicopter/on-land inspections while increasing precision and frequency of inspections for above ground sub-transmission network. The Visual Intelligence solution automated the inspection process by generating a Network Digital Twin, detecting vegetation encroachment risks and providing predictive pruning strategies and accurate asset defect detection. The results:



- Completeness of automated asset classification in the Network Digital Twin: 95%
- Reduced vegetation management costs by 27%
- Reduced legacy inspection related downtime by 30%

By collecting visual inspection data, GE Digital's Visual Intelligence cloud-based platform's Network Digital Twins of critical infrastructure run automated machine learning analytics to manage the data, analyze and visualize maps and other information, and develop and integrate programs to address potential issues. Key platform capabilities include:

- Support for ingestion of all major visual inspection files types (RGB, LiDAR, Hyperspectral, FLIR, and Satellite) captured by utilities, any third party, or by GE
- Easy integration with any GIS, ADMS, EMS
- Built-in SDK to develop new applications or train new models and AI engine for auto-recognition and prediction
- Vegetation Management and Asset Inspection on the same platform
- Easy to use and interactive: view, measure, annotate, and share actionable data

GE Digital's Visual Intelligence platform is generally available. More information can be found here.

GE Digital | www.ge.com/digital/

Battery Crimper

BURNDY has released the new Patriot PAT444ST3 Dieless C-Head Battery Crimper Series with T3 Technology. The crimper has all the features of its Patriot predecessor, plus a new ergonomic design and state of the art technology. The TRACK-TRACE-TRANSMIT (T3) intelligence feature provides critical crimping information for all projects small and large. Data collected by the PAT444ST3 allows users to know that their BURNDY crimper is performing to specification and enhances the application of the BURNDY Engineered System.

BURNDY | www.Hubbell.com

Air Leak Detection

Vaisala is bringing to the market an accurate and reliable method for detecting air ingress in sealed power transformers. With the increased number of sealed transformers, ambient air leaks have become a significant issue as oxygen accelerates the aging of paper used in the insulation.

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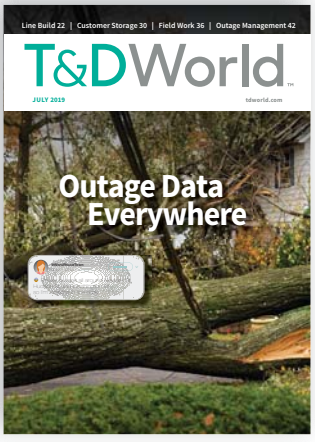

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Utility Analytics Institute is a growing online community and membership organization for power utilities looking to optimize data analytics to improve their business.

ENDEAVOR BUSINESS MEDIA

Measuring total gas pressure (TGP) is a step forward from the traditional measurement methods that are currently available in the market to detect air leaks. An oxygen sensor cannot detect an air leak, if there is a reaction in a transformer that consumes oxygen. Even if all oxygen has been consumed, TGP value will still give a reliable indication of a leak because the nitrogen value will both dominate and increase over time because it is neither formed nor consumed in the transformer. Additionally, TGP measurement can indicate if the nitrogen cylinder of a nitrogen blanketed transformer is empty — another task that oxygen measurement cannot detect.

The new measurement solution will be made available to the current customers via a software release for Vaisala's Optimus DGA Monitor OPT100, which is a maintenance-free dissolved gas analyzer for power transformers. For new OPT100s, the new software will be incorporated as a default factory setup.

Vaisala | www.vaisala.com

Network Camera

Vivotek is upgrading to the VCA package version 6.6 for its MS9321-EHV 20MP 180 degree panoramic network camera with VAST 2 technology, users are provided VIVOTEK's Smart VCA package free-of-charge without the need for a license.

Featuring 4 x 5MP CMOS sensors at 30fps at all resolutions, the MS9321-EHV multiple sensor network camera can monitor full 180-degree horizontal views and deliver comprehensive coverage, making it a sutiable outdoor surveillance solution. The MS9321-EHV has the video alignment feature that allows you to adjust the positioning and image quality of each sensor, enabling users to view a seamless picture, with no repetition. The version 6.6 VCA package includes a suite of seven video analytic rules/functions:

- Intrusion detection
- Loitering detection
- Line crossing detection
- Unattended object detection
- Missing object detection
- Face detection
- Crowd detection

Along with Trend Micro IoT Security and a weather-proof IP66-rated and vandal-proof IK10-rated housing, integrated Smart IR II technology with adaptive IR enables the MS9321-EHV's 30M 180-degree IR illuminators to adjust to the scene together or individually to provide the best possible IR image, reducing glaring hotspots and/or underexposed dark spots. With WDR Pro (120dB), the MS9321-EHV captures both the dark and bright areas of an image and combines them to create a highly realistic representation of the original scene. Lastly, combining both H.265 and VIVOTEK Smart Stream III, the MS9321-EHV can reduce bandwidth and storage consumption more than 90% (depending on scenes) compared to traditional H.264 without smart streaming.

Vivotek | www.vivotek.com

Transmission Line Relay

The SEL-T401L is a new transmission line relay that combines time-domain technology and phasor-based protection in a single device. The new line-monitoring feature makes it the only relay capable of detecting and locating incipient faults. In addition, the SEL-T401L features traveling-wave-based fault-locating methods, location-dependent autoreclose cancel logic, and high-resolution transient recording. Suitable for a wide range of applications, the SEL-T401L offers an opportunity to reset the complexity of line protection applications with simple protection philosophies and a reduced setting count. The combination of time-domain technology and a complete suite of phasor-based protection functions makes the SEL-T401L an ideal choice for state-of-the-art transmission line protection. The time-domain protection elements and schemes operate in 1–5 ms, and the distance protection elements operate at subcycle speed. The relay is well suited for lines near nonstandard generators, such as wind generators or inverter-based sources; in low-inertia systems with HVdc links; and in systems with series compensation.

The new line monitor feature can detect and locate low-energy transient events, which are indicators of potential future faults. The line monitor will detect, locate, tabulate, and alarm for discharge across dirty or damaged insulators, incipient cable faults, discharge from encroaching vegetation, and other events not accompanied by protection operation.

Schweitzer Engineering Laboratories | www.selinc.com

Voltage Transformer

The TSTM Powerpuck provides clean power at your choice of voltage, selectable on-site. These weather-proof toroidal autotrans-formers can be configured to provide nearly any commonly used voltage you may expect to require: 480/360/240/120. The Powerpuck is designed for a variety of applications where a grounded neutral is not available to establish a common. Easily installed, whether inside a cabinet or exposed to the elements through a knock-out, the tordoidal designs reduce transformer ringing and carry a 15-year guarantee against failure.

Like a Swiss Army* Knife, the user can carry it along and choose the voltage "tool" as needed. For example, irrigation consumers need only the three "hot" phases from a 480/277-V, 4-wire wye transformer bank for a three-phase pump motor in the middle of a field. If 120 or 240 is required for load control this transformer is perfect, with no need to dangerously use a hot phase as a common. *Swiss Army is a registered trademark of Victorinox AG, Ibach-Schwyz, Switzerland.

TSTM Inc. | ts-tm.com

Dead Tank HV Circuit Breaker

Meidensha Corp. (Meiden) has added to its line of dry air insulated vacuum circuit breakers. Using dry air as the insulating medium, Meiden's HV breakers offer the industry a solution to SF6, a potent greenhouse gas. Meiden's second circuit

breaker design follows the 72 kV class, which was introduced in 2004 to global utility and industrial users. Designed with dedication to the environment and safety for all personnel, over 800 units have been supplied with reliable performance to the North American market.

Some of the characteristics of the environmentally friendly 145kV VCB include;

- Dead tank design
- Tested to ANSI, IEEE and IEC standards
- 40kA interrupting capability
- Up to 3150 A
- Spring motor
- Composite or porcelain bushings
- Fully assembled for shipment
- Easy to maintain
- Dry air insulated
- Bushing mounted current transformers

Meiden will manufacture the 72 kV and 145 kV class breakers in its new southeastern U.S. facility beginning in late 2020.

Meiden America Switchgear | www.meidensha.com

Pole Stabilization

The Direct Embed Pole Stabilization (DEPS) system from LineWise is a new bracing system for holding concrete or steel poles in place while pouring concrete or FlowFill. This cost-effective solution offers a quick and easy setup that significantly reduces equipment and labor costs. The DEPS system consists of two or more adjustable pole braces for each pole that is being stabilized. The pole braces are first chained or strapped to the base section of a pole. Then, the anchor plates are staked into the ground, and the pole is plumbed by simply extending or retracting the braces. The entire process can be completed in minutes. Compared to the traditional alternatives of using forklifts, telehandlers or deadman concrete anchors to support poles during construction, the DEPS system eliminates the cost of equipment rentals, machine maintenance, fuel, and other various tools. Reduced environmental impact is another great benefit of using the DEPS system: fewer vehicles on the jobsite means reduced emissions and fewer ruts in the right-of-ways.

Diversified Products | line-wise.com

Ground Mat

Hastings' portable protective Ground Mat provides a method for workers to establish an equal potential zone for multiple grounding applications. The Ground Mat is manufactured of vinyl polyester fabric, with high ampacity, tinned-copper braid sewn into a grid pattern. The braided copper on the grid connects to a six-inch termination stud on the corner of the mat. The Ground Mat is then bonded to the equipment being worked on by using a safe and reliable ground cable assembly. The mat is available in three sizes and two different types of material: standard yellow and black anti-skid. Multiple mats can be bonded together. These mats are also reversible, easy to store, and easy to clean with standard hose pressure or power washer.

Hastings Fiber Glass | www.hfgp.com/

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a. Total number of copies (net press run)	25,852	24,179
b. Legitimate paid and/or requested distribution (by mail and outside the mail)		
1. Outside-county paid/requested mail subscriptions stated on PS Form 3541	22,783	21,247
2. In-county paid/requested mail subscriptions stated on PS Form 3541	0	0
3. Sales through dealers and carriers, street vendors, counter sales, and other paid or requested distribution outside USPS	604	498
4. Requested copies distributed by other mail classes through USPS	0	0
c. Total paid and/or requested distribution	23,387	21,745
d. Nonrequested distribution (by mail and outside the mail)		
1. Outside-county nonrequested copies stated on PS Form 3541	901	873
2. In-county nonrequested copies stated on PS Form 3541	0	0
3. Nonrequested copies distributed through the USPS by other classes of mail	0	0
4. Nonrequested copies distributed outside the mail (Include pickup stands, trade shows, showrooms and other sources)	340	379
e. Total nonrequested distribution (Sum of 15d (1), (2), (3), and (4)	1,241	1,252
f. Total distribution (Sum of 15c and 15e)	24,628	22,997
g. Copies not distributed	1,224	1,182
h. Total (Sum of 15f and 15e)	25,852	24,179
i. Percent paid and/or requested circulation (15c divided by 15f times 100)	94.96%	94.56%

16. Total circulation includes electronic copies.

a. Requested and paid electronic copies	–	–
b. Total requested and paid print copies (Line 15c) + requested/paid electronic copies (Line 16A)	23,387	21,745
c. Total requested copy distribution (Line 15f) + requested/paid electronic copies (Line 16a)	24,628	22,997
d. Percent paid and/or requested circulation (Both print and electronic copies) (16b divided by 16c x 100)	94.96%	94.56%

17. Publication of Statement of Ownership is required and will be printed in the November 2020 issue of this publication.
18. Sonja Trent, User Marketing Manager, 09/18/2020
I certify that all information on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties).

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Duke Energy
What do you do with dozens of T-shirts you collected from events? Gerald Parks had a quilt made.

Entergy Louisiana
@EntergyLA
Less than a day after hearing he was cancer-free, @DukeEnergy lineman Tyler Manick knew what he needed to do first: help the people of southwest Louisiana. We appreciate all our mutual-assistance crews helping us restore power after #Delta. #PoweringThru

Eversource Energy
We're sending a big thank you to our lineworkers who help keep the power flowing to our customers every day. Your hard work and dedication are appreciated, especially during these challenging times. Happy Lineworker Appreciation Day! #ThankALineworker #PoweringThruTogether

Tadano Mantis Cranes
@TadanoMantis
It's @tdworldmag Lineman Celebration Week! Tadano Mantis Cranes have supported powerline & transmission pros on tough jobs for years, and we appreciate their quality and consistent work. *https://rb.gy/scu0o6 #ThankALineman #UtilityHeroes*

Pacific Power
Good, clean fun from Portland to the Coast. Pacific Power employees teamed with SOLVE and Alberta Main Street for a volunteer clean-up weekend in Seaside and Northeast Portland.

Tennessee Valley Authority
That's a good boy! Pups in shelters around the Valley are loving donations of tennis balls from our Economic Development team, as we celebrate receiving Site Selection's top utility award for 15 years in a row!

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What's Driving Distributed Generation Adoption?

By **Gilbert Michaud**, Ohio University

For much of the United States' power grid network's 100-plus year history, utilities have been unchallenged monopolies because of barriers to market entry, among other reasons. Traditionally, electricity generation in the U.S. has relied on large, centralized assets, such as coal-fired power plants, to achieve economies of scale and to supply inexpensive and reliable power to customers. However, as steep cost declines have enhanced the price competitiveness of alternative energy resources, a greater level of investment in such technologies has ensued.

Home and business owners have been at the forefront of this contemporary energy transition, often via the adoption of behind-the-meter distributed PV or micro wind turbines, also referred to as distributed generation (DG). Though still in its relative infancy, the exponential increase of DG has been revising the traditional electricity procurement model and forcing the utility industry to adapt. While there have been numerous arguments both for and against the value of DG, many utilities are now embracing DG, or at least exploring the prospect of doing so.

Arguments in favor of DG deployment have been led by environmental organizations, the renewable energy industry, and more progressive politicians. One argument, of course, relates to the myriad environmental benefits of DG, such as reduced greenhouse gas (GHG) emissions, compared to conventional generation via fossil fuels. Another pro is how DG can enhance economic development by creating and supporting jobs in industries such as solar module manufacturing or installation, in addition to stimulating local tax contributions for governments.

One advantage of DG that has unexpectedly come in handy in the face of COVID-19-related disruptions is the stability that localized, renewable energy can provide, particularly as remote work and social distancing — at least in the short term — have become the new norm. Recent years have also given rise to growing concerns around emergency preparedness and being able to have resilient power sources in the event of grid disruptions.

Conversely, many have pushed back against the "disruptive challenge" of DG deployment, including, at least historically, electric utilities themselves. One argument is that lower revenues, given the decreased amount of electricity being purchased by ratepayers, has affected utilities' bottom lines. Others have cited that DG is too intermittent to be reliable during peak hours. Another argument is that state net-metering laws have created a cross-subsidization situation, in which utilities have raised rates to cover grid upkeep, which are costs that are passed on to non-net-metering customers. Some utilities have taken it a step further by implementing monthly stand-by charges for solar PV owners to help cover these costs.

Despite these convoluted circumstances, some utilities are now more formally embracing DG. One reason is state renewable portfolio standards (RPS) mandates that require a certain percentage of regulated utilities' electricity mix to come from renewables, such as solar and wind. Often, instead of costly build-out of their own renewable generation, utilities will gladly purchase renewable energy credits (RECs) from local consumers to meet state RPS targets. DG also offers the opportunity to avoid or defer generation capacity. Avoided T&D costs can provide a cost benefit to the utility and its customers.

Consumer demand has also largely driven utilities' move toward DG. This includes households, as well as large corporations like Amazon, Google, and Facebook who demand cheap and reliable power, and have targeted corporate sustainability missions. Many pioneering utilities have realized this value proposition and have started to employ strategies to allow large corporations to develop DG.

Obviously, not all electric utilities are embracing DG. Traditionally, large, investor-owned electric utilities have been more hesitant to welcome competition in this market, but cooperatives and municipally owned utilities have been more democratic, flexible, and open to local innovation. Many cooperatives have implemented unique adoption programs, or even community solar projects that enhance market access to those that cannot otherwise adopt DG, as seen in Minnesota.

Either way, if utilities see ways in which DG can help them reduce or avoid infrastructure costs, as well as keep both large and small customers with new preferences happy, they will continue to tolerate additional adoption. Doing so, in turn, may create added benefits by way of peer effects and co-adoption, in which the deployment of other advanced energy technologies, such as battery storage and electric vehicles occurs. This will also create a more modern and customer-centric grid.

By being receptive to public demand and encouraging more objective research on the proper integration and costs and benefits of DG, utilities can be part of a just energy transition while also maximizing their own benefits and minimizing negative impacts to their operations.

How can utilities derive more value from the already emerging DG markets? How will they adapt to the new grid of the future, which creates jobs and is part of a lower-carbon economy? The next decade will address these tough questions, as we see leader utilities emerge and laggard utilities fall behind during this industry shake-up. For many, it may be a classic case of, "If you can't beat 'em, join 'em."

Gilbert Michaud is an assistant professor of practice in the Online Master of Public Administration Program at Ohio University.

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