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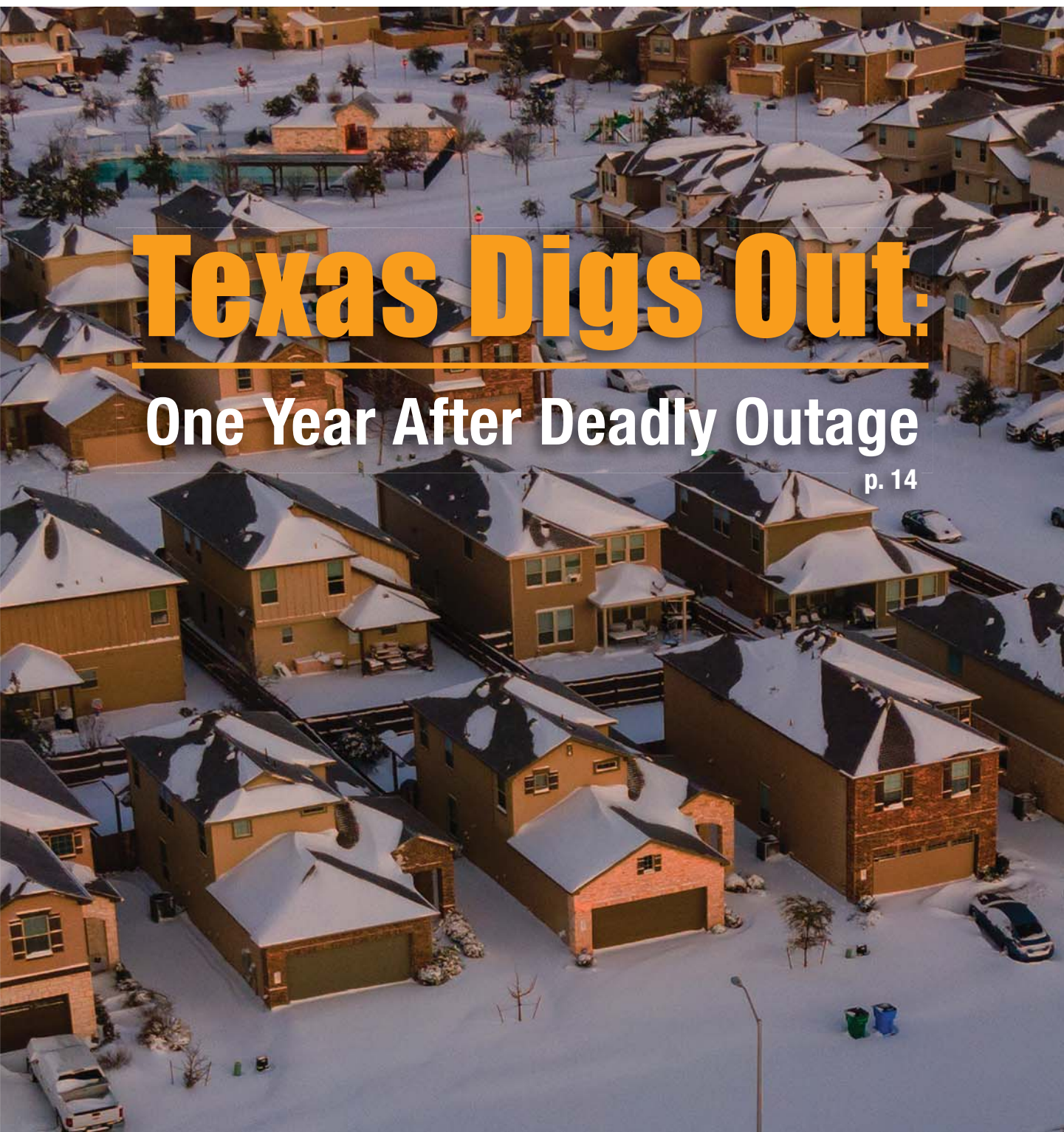

Texas Digs Out:

One Year After Deadly Outage

p. 14

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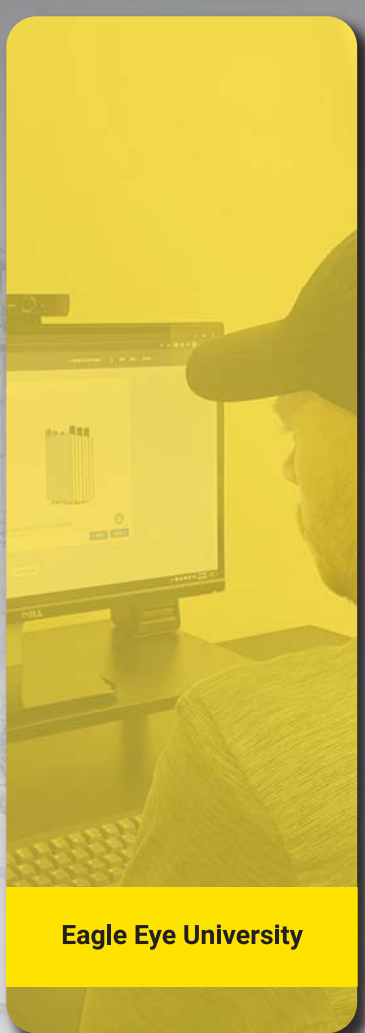

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IN THIS ISSUE

Vol. 74 | No. 2

14 Texas' Big Freeze:
Lessons Learned One Year Later

OUTAGE MANAGEMENT

By **JEFF POSTELWAIT**, Senior Editor

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Wildfires Remain Hot Topic in 2022

Mother Nature is fickle. She can be a wonderful friend or a fearsome adversary, depending on the day, or even the hour. While many of us were enjoying the warmest Christmas week ever, for thousands of people living between Denver and Boulder, Colorado, that warm, dry weather created a nightmare. On Dec. 30, several thousand people were told to immediately evacuate their homes and businesses as a 6,000-plus acre wildfire quickly spread into heavily populated areas. Nearly 1,000 homes and businesses were destroyed before firefighters extinguished the fire with help from a significant snowfall the next day. This Colorado fire was just the last of several wildfires that occurred in 2021 and is among a long list of natural disasters that have plagued not just the U.S., but many parts of the world over the last couple of decades. When it comes to wildfires, Wildfires can cause massive destruction to electricity infrastructure, and too often that infrastructure is discovered to be the initial source of the fire. When that's the case, the loss of infrastructure becomes a secondary problem for the utility that owns and operates the T&D grid.

It's unfortunate that early news reports from Colorado said the fire started from a downed powerline. This was reported before officials even began to investigate the fire's cause, and investigators have since ruled out downed powerlines. The fact that the electric utility was initially blamed, however, is an indication of the difficult situation some utilities face when trying to provide safe, reliable and affordable power.

Affordability is definitely at stake for some Western U.S. utilities that must contend with wildfire risks. On Dec. 16, 2021, Southern California Edison (SCE) became the latest utility to pay hefty fines and penalties for its role in five 2017 and 2018 wildfires that together burned more than 380,000 acres and destroyed thousands of homes. The utility's settlement with the state's Public Utility Commission (PUC) requires its shareholders to pay a $110 million penalty to California's general fund and $65 million toward improved safety measures. The settlement also prevents SCE from passing along to its customers $375 million in costs incurred due to fire-related insurance claims. The complete settlement carries a price tag of $550 million. That's a lot of money, most of which won't be available for SCE to invest in technologies and other measures that will reduce the risk of future wildfires.

SCE's recent settlement is just one of several similar settlements in California. The California PUC reached a $125 million settlement, also in December, with Pacific Gas & Electric (PG&E) for the 2019 Kincade Fire, which was PG&E's most recent but not its first wildfire payout. In mid-2020, the utility emerged from Chapter 11 bankruptcy attributed to more than $30 billion in liabilities from 2017 and 2018 wildfires started by its powerlines.

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It's easy to see why California utilities have taken the lead on wildfire mitigation strategies. The recent Colorado wildfire illustrates, however, that other U.S. utilities also must take the risk seriously. Extended droughts (blamed primarily on climate change) in many parts of the country make numerous utilities vulnerable to wildfire risks.

It's also easy to see why *T&D World* readers are especially interested in utility best practices for wildfire mitigation and response. The Wildfire section on *T&D World's* website is one of our most visited pages and our free "Wildfire Risk Mitigation Volume 2 eBook" released in April 2021 has been a huge success. If you want to learn how Bonneville Power Administration, SDG&E, SCE and Bear Valley Electric are addressing wildfire issues, you should download it. As I mentioned, it's free.

We published several wildfire-related stories in *T&D World* in 2021, and as the editorial team plans its 2022 content, wildfire stories will be an even bigger part of our coverage. We are putting together a special supplement in May's print and digital issues, as well as planning a series of webinars on the topic.

Utilities and the solution providers with which they partner are creating and applying technologies and processes that are making great strides in wildfire prevention and management. Many of these utilities and companies are sharing their strategies and lessons learned with *T&D World* so that we can share them with you.

While they are the real champions in this fight, we at *T&D World* are honored to be able to play a small part in helping protect lives and property from wildfires. If you have wildfire stories to share with us or wildfire-related topics you'd like for us to cover, let us know. You can reach out to the editorial team through the "Contact Us" feature at the bottom of our home page. TDW

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A Teachable Moment Regarding Transmission Development

In late 2021, a New England state environmental agency suspended the permit for a major new transmission line after construction had begun. The agency's action appears to have been influenced by a statewide public referendum that opposed the project. Obviously, project suspension and potential cancellation after start of construction is the worst nightmare of every utility executive. This type of event was unheard of 30 years ago when many major projects were developed. Are utilities forgetting some key aspect of successful project development or has the world changed, or both?

The 1970s witnessed the twilight phase of the greatest electric transmission development era so far in the U.S. A new law, the National Environmental Policy Act or NEPA, required proposed projects to conduct a lengthy environmental review process. NEPA covered not only major transmission projects, but also power plants, pipelines and transportation projects with potentially significant environmental impacts. While burdensome, triggering NEPA results in the development of an independent environmental impact statement (EIS) that evaluates the positive and negative effects of the project, offers alternative actions, including inaction, and thoroughly vets federal, state, and local agency as well as public sentiment regarding the proposal.

There are shortcuts in the federal law that allow avoidance of a major EIS, which seems the more common path today. However, many states have detailed review proceedings for proposed major projects, which include a public hearing and comment process. Historically, utilities and authorities involved in the development of major linear corridor projects possessed a deep bench of support staff experienced with public participation. Corridor projects may affect a large swath of the public with impacts ranging from visual intrusion to outright displacement. It is especially critical to ensure everyone's input is incorporated into project decisions under such circumstances and methods such as the Nominal Group Technique can be used to achieve as much consensus as possible.

What is going wrong with projects today that are suspended or canceled post start of construction? Are we not doing an adequate job of incorporating the input of all stakeholders or resolving major conflict during the development stage? If parties remain opposed to a project after a final decision is made, have we reached a time in our society that the risk of proceeding with a project may be too great even if an approval has been granted? In the project sited above, the primary benefits appear to accrue to one state and most opposition as well as the agency suspending construction are from another. In fact, the issue on the ballet in the opposing state, which could permanently enjoin the project under construction, supports local transmission while increasing the difficulty of gaining approval for EHV and DC transmission that does not directly benefit the local communities it impacts.

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The Infrastructure Investment and Jobs Act (the Act) passed in November 2021 grants FERC broader transmission siting authority within national interest transmission corridors and allows the DOE to become an anchor tenant for new transmission projects. We should be able to review the record regarding gas pipelines to determine whether FERC or DOE involvement in siting or as an anchor tenant in new transmission projects triggers a federal EIS. Pipeline development records also will provide insight as to whether federal siting authority has assured the completion of approved projects historically.

Frankly, we do not know if the Act will help get new transmission built. Unquestionably, it has never been more difficult to obtain consensus regarding major new long distance, interstate, and international transmission projects. Such projects should be designed to deliver demonstrable benefits outweighing the impacts for all affected parties. Rapid growth of and support for DERs does not comport with arguments by policy makers that new transmission is needed to transport or import renewable energy. DERs and other regional resources provide power, jobs, and economic development locally without impacting communities not receiving benefits from remote projects or long distance transmission.

Transmission developers may need to borrow from other energy business segments to provide compelling economic strategies for landowners, host communities and other stakeholders to support new projects. The outright purchase of the required land for a project as opposed to a one-time purchase of a ROW is one example utilities have employed. Offering a production-based payment to landowners and providing a community stipend or other benefits has proven successful in the gas exploration and wind industries. Applying these methods to transmission projects would ensure those living with the project will receive continuing tangible benefits. The power industry is operating in a new era of public activism complicated by policy driven as opposed to strictly need based infrastructure development goals. Successful future projects will require in depth collaboration to get all stakeholders on board and rowing in the same direction. TDW

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Technology And The Human Factor

We have become addicted to digital technologies, but when all things are considered, they are really important tools for both daily life and for work. The advancement of digital technologies has revolutionized every part of today's world. This transformation has been so influential, it's referred to as Industrial Revolution 4.0. But there is some apprehension.

Consciously and subconsciously, we ask, "Do we trust modern technology to perform as promised?" The trust factor is one of the biggest hurdles when it comes to adopting digital technologies. I started thinking about this subject because of a TV commercial I had seen. A salesperson led the barefoot customer to a standup scanning pad. While the scanner worked, the narrator told how the device made a virtual 3D foot model within a few millimeters of precision.

1972 Hewlett-Packard scientific pocket calculator: HP-35. Seth Morabito, CC BY 2.0 , via Wikimedia Commons

Do We Trust Technology?

It played up how the state-of-the-art scanning device ensured a perfect fit, but then what I call the "human factor" took over. The scene shifted, the salesperson was now sitting in front of the customer measuring their foot again. Only this time with the traditional Brannock metal foot measuring device, circa 1927. What happened to the cutting-edge 3D scanner?

I'm guessing this mistake wasn't planned. More likely this was a video moment to introduce the shoe being sold rather than a statement about technology. But it does play to the subliminal need we have to verify the accuracy of our technology. Still, the comparison between the scanner and the Brannock device had me chuckling a little.

It also brought back an early memory of how technically inclined people corroborate technologies in not so veiled ways. In 1972 Hewlett-Packard (HP) introduced the world's first scientific pocket calculator. The HP-35 was such a breakthrough that every engineer wanted one, but they were expensive (around $2,500 in today's dollars).

And like the 3D foot scanner, there was the human factor effect here too. Many of my friends fortunate enough to be able to afford one usually checked the little computer's answers with their trusty, 1600s-circa slide rules. It wasn't that they didn't trust the HP-35, but it took a while for them to be comfortable with the technology, and the human factor required proof.

I'm sure some readers think we have moved beyond that in today's digital world, but the human factor is still alive. And that includes our power deliver system with all of its cutting-edge smart grid technologies. We trust technology, but we have an intrinsic need to authenticate it.

Test and Test Again

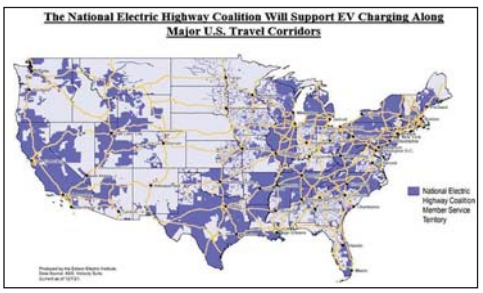
One of my favorite examples is the dynamic line rating (DLR) technology. It's been around since the 1990s. Many studies have shown transmission line ratings could be increased by 10% to 25% with the addition of DLR technology, but that's not happening. The U.S. is still in the validation phase for DLR applications with pilot projects while other countries install them. Keeping it simple for those not familiar with transmission line rating methods, traditionally tables (static line ratings) are used to determine transmission line capacities.

It's a system based on conservative assumptions concerning weather conditions and conductor heating. It was developed by a group of transmission engineers in the 1930s. The tables proved popular, and have been used ever since. Considering the timeframe it was truly a marvel, but that was almost a hundred years ago!

Granted, the first generation of DRL devices were very primitive and hard to use compared to today's generation of platforms. Today, a lot has changed both gridwise and with the latest generation of DLR technologies. These systems are really user-friendly and employ everything from LiDAR and satellite radios to artificial intelligence. They provide real-time transmission line ratings 24/7. They are also easy to install. Some don't even require the monitoring equipment to be attached to the conductors. Check out equipment from companies like EDM International, Lindsey Manufacturing, LineVision, and others to see what is available.

After the Department of Energy noted the U.S. lags behind other countries in the deployment of DRL technology the Federal Energy Regulatory Commission proposed rulemaking that could expand DLR technology use on the U.S. grid. Will it overcome that human factor? That's hard to say, but there are several active DLR projects taking place in the U.S. and it's timely. With all the attention focused on our infrastructure, DLR technology appears to be an ideal solution for increasing the nation's transmission capacity with little disruption. It's going to be interesting! TDW

Utilities Join Together To Build A Nationwide EV Charging Network



Electric Companies Join Together to Form National Electric Highway Coalition.

One of the major drawbacks to owning an electric vehicle is finding a charging station away from home, especially if the owner is interested in doing cross country driving. Well, that is changing, and it's changing big time. The Edison Electric Institute (EEI) announced the formation of the National Electric Highway Coalition. This coalition merges the Electric Highway Coalition and the Midwest Electric Vehicle Charging Infrastructure Collaboration. It also includes additional participating electric companies from across the country.

The coalition now consists of 51 investor-owned electric companies, one electric cooperative, and the Tennessee Valley Authority. It is committed to providing EV fast charging ports that will allow the public to drive EVs with confidence along major U.S. travel corridors by the end of 2023.

"EEI and our member companies are leading the clean energy transformation, and electric transportation is key to reducing carbon emissions across our economy," said EEI President Tom Kuhn. "With the formation of the National Electric Highway Coalition, we are committed to investing in and providing the charging infrastructure necessary to facilitate electric vehicle growth and to helping alleviate any remaining customer range anxiety."

To date, EEI's member companies have invested more than US$3 billion in customer programs and projects to deploy EV charging infrastructure and to accelerate electric transportation. As EV sales continue to grow, EEI estimates that more than 100,000 EV fast charging ports will be needed to support the projected 22 million EVs that will be on U.S. roads in 2030.

"By merging and expanding the existing efforts underway to build fast charging infrastructure along major travel corridors, we are building a foundational EV charging network that will help to encourage more customers to purchase an electric vehicle," said Kuhn. "We owe a great deal of gratitude to the electric companies that created so much momentum at the regional level, paving the way for us to expand this effort nationally."

"We are delighted to see this collaboration come together with both regional and national scopes to develop a framework and to provide charging stations across state boundaries," said Alliance for Transportation Electrification Executive Director Philip B. Jones. "EV owners want to charge conveniently and quickly without a fear of running out of electric fuel. Moreover, the EV industry, led by electric companies and cooperatives, automobile OEMs, and EV service providers, need to accelerate the deployment of charging infrastructure now. With scores of new battery-electric vehicles coming to market over the next couple of years, we need to get the charging infrastructure sited, built, and funded. The federal infrastructure funding will help a great deal in this effort, but this is only a down payment of a much larger effort. Electric companies, which are regulated by state commissions, can help leverage all funding sources, help fill the infrastructure gaps, and help manage the deployment of these chargers with a long-term view."

California Utilities Working With Swell Energy to Advance Virtual Power Plants

Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E) have announced they are working with Swell Energy Inc. on pilot projects to expand grid services use cases for residential solar + storage resources to meet both local and regional energy needs.

PG&E and SDG&E are working with Swell to expand residential participation in their respective Capacity Bidding Programs. Through these programs, homeowners with solar + storage systems can receive compensation for supporting overall grid reliability while maintaining reserves in their battery for emergency use. These efforts support the California Public Utility Commission's goal of reducing load during California Independent System Operator emergency power events.

For PG&E, Swell will enroll existing and new residential solar + storage customers into the Capacity Bidding Program and collectively manage the systems to provide needed capacity during times of high demand or high wholesale market prices. For SDG&E, Swell is expanding residential participation in its program, which was previously only offered to commercial and industrial customers. In addition, Swell is helping SDG&E evaluate different scenarios in which residential solar + storage systems could be used to improve the overall reliability of the grid in the context of SDG&E's specific goals and constraints.

Swell is also working on innovative virtual power plant applications with Southern California Edison (SCE). In addition to the two existing virtual power plants Swell has with SCE, the smart grid solutions provider is facilitating expanded applications for residential solar + storage assets to balance energy on the grid across a number of different scenarios and use cases. The effort with SCE could expand the use of aggregated residential solar + storage resources into virtual power plants to maximize environmental benefits and improve power reliability for SCE customers.

All three programs align with California Public Utility Commission goals to improve power reliability in the face of more frequent extreme weather events. By expanding residential participation in utility capacity programs, these programs are helping utilities maximize the benefits distributed solar + storage systems can provide. With the right grid services and participation levels, these programs help utilities and the California Public Utilities Commission meet California's mandates for renewable energy while improving power reliability. TDW

Virtual Power Plants: Some Assembly Required

There has been a major shift in the power grid's opinion of aggregated BTM-DERs.

It's getting harder to remember that distribution energy resources (DERs) started out on a very small scale when marketing research groups are predicting these devices will grow to somewhere around 400 gigawatts (GWs) by 2025. That's a great deal of electricity generation, especially when you consider it is a behind-the-meter (BTM) power source. As staggering as that figure is, there are those projecting the global virtual power plant (VPP) market will reach about US$1.5 billion or more by 2026.

All of these estimates and projections are based on some solid digital technological advancements being applied to the smart grid. Where once VPPs were merely interesting niche experiments, many experts are now saying that VPPs have the potential to becoming a grid changer. The power grid is modernizing, and one area identified is decentralizing the power generation infrastructure and VPPs are seen as a critical step in this process.

Interestingly, it was two years ago this month that "Charging Ahead" first reported on VPPs. At that time, VPPs were one of those applications that appeared to be getting some attention, but not enough consideration to be more than a niche market. There were too many significant concerns needing attention to have many jumping on the bandwagon. Still many authorities thought VPPs were a trending technology with the potential of changing the grid, which is correct today. So, it's time to revisit the topic and see what is driving it.

A Different Concept

During those past two years, there has been a lot happening with BTM-DER technology. So much so that VPPs are more commonplace worldwide than ever before. There has also been a major shift by the power delivery industry in how VPPs are perceived. This shift started with the customers and has slowly moved to the utilities, regulators, and independent power providers. Several experts credit dropping prices for solar panels and the availability of energy storage batteries, but that is only part of the story.

VPPs are more than hardware, and there are other influences at work, which are coming together at the right time. The logical starting point is the Internet of Things (IoT). Initially IoT was more oriented toward toasters and thermostats than DER devices. But as IoT technology matured it starting branching off into specialized grouping. In the power delivery industry we focused more on IIoT (Industrial Internet of Things), UIoT (Utility Internet of Things), and IoTSP (Internet of Things Services and People).

AlexLMX/Getty Images

These specialized categories take advantage of smart devices connected to and controlled by various forms of cloud-based computing. This development set the stage for what has been called the IT/OT convergence. This advancement allows IT (information technology) and OT (operational technology) systems to combine into a single platform. Rather than repeating the information here, see the September 2021 "Charging Ahead" *https://tdworld.com/21171943* for IT/OT details. Technologically this was a pivotal point in the advancement of VPPs, but there are also other forces at work too.

It Starts Getting Interesting

One of the most surprising VPP influencers has been the impact of global climate change. Because of ever-changing weather patterns, extreme weather-related events (i.e., wildfires, ice storms, back-to-back category 5 hurricanes, etc.) have led to prolonged power outages. Frustrated customers found their own solutions to extended outages. They added energy storage to their DER systems. In effect turning them into BTM nanogrids and microgrids with sophisticated hardware and software supplied by companies like Eaton, GE, Hitachi Energy, Schneider Electric, and Siemens Energy to name a few.

The timing was spot on with actions being taken by regulatory bodies and legislatures in the form of support for the BTM-DERs. In the U.S., there were several important rules issued by FERC (Federal Energy Regulatory Commission) that addressed DERs and the grid, but Order No. 2222 was critical. In FERC's words, "This rule enables DERs to participate alongside traditional resources in the regional organized wholesale markets through aggregations, opening

U.S. organized wholesale markets to new sources of energy and grid services." In simpler terms, the order opened the wholesale power market to BTM-DER technology.

The support had the desired affect with both utilities and aggregators announced grid-scale VPP projects taking advantage of the support and the technologies. This is where another technological advancement comes to play. How can thousands of BTM-DERs be controlled to perform like a multi-megawatt central generating plant? At the heart of the control system is the ability to gather data, analyze it, and act on it.

Digitalization of Energy

Talking with Tilo Buehler, global product manager, Grid Edge Solutions, Hitachi Energy and Nicholas Heine, Digital & Service Manager, Hitachi Energy answered a lot of questions about the intricacies of controlling VPPs. Buehler opened the discussion saying, "Technology is key to making a VPP work. Having a solid software foundation is the best way to ensure success of deployment, like the e-mesh portfolio, that covers the on premise, as well as the aggregated control algorithms. DERs are foundational to VPPs, but communication infrastructure is the most important technology to orchestrate them."

Buehler continued, "This software needs to aggregate and collate different devices, take signals from system operators, and connect ISOs into distributed resources. The control layer is important for "number crunching" and assigning a suitable amount of contribution for all DERs to achieve an effective MW output. Without a communication and control layer and DERs, VPPs won't work."

Heine added, "Artificial intelligence/machine learning (AI/ML) and data analytics play a greater role in 'auto bidding,' a way of forecasting how to make the most of capacity and prices in the energy market. The better the forecast, the better the decisions made. AI/ML and analytics can forecast what to bid for greater return to DER customers and VPP vendors. These technologies can also be used to forecast peak times for generating renewable energy and calculating output needed based on that."

Both agreed, "The move to digitalization in the energy industry is huge. Communications and software are elements the traditional grid hasn't put at the forefront, and instead designed a more passive grid. In traditional set ups, network operators would build additional capacity and network, and if anything went wrong, there's still enough capacity to keep the lights on. VPPs respond proactively to an abnormal situation but need connectivity and software to make this approach work. In this case, the skills of power workers need to evolve to manage this."

They finished the discussion saying, "It's possible to upskill the current workforce to support these new digitized efforts, but it's also important to invest in the best talent focused on these emerging areas. For example, the forecasting piece of VPPs could be the difference between one company and its competitors returning more value, and that could affect winning contracts. More data, sophisticated algorithms and people who know how to manage both will lead to a more successful business overall."

Petmal/Getty Images

Tangible Results

Utilities have been working with aggregators and independent power producers create VPP programs. This is especially true in California. If a customer owns Tesla's Powerwall in California, there are plans enabling them to join Tesla VPP programs in Pacific Gas & Electric, Southern California Edison, or San Diego Gas & Electric's territories. Swell Energy is also working with these three utilities on VPP projects. In addition Swell is also working on VPP projects in New York and Hawaii.

Next Kraftwerke, a wholly owned subsidiary of Shell, operates one of the largest VPPs in Europe. According to their website they manage 12,343 aggregated units with a network capacity over 9.8 gigawatts (GW). VPP activity is taking place Asia too. Singapore selected Hitachi Energy to supply its e-mesh PowerStore battery energy storage technology with its intelligent digital control system for Singapore's first VPP. That VPP project's goal is validating methods for integrating more renewable energy onto the city-state's electricity networks.

These are only a few examples of the VPP activity taking place worldwide, but they show the BTM portion of the grid is changing. VPPs are a relatively new technology, and they are already improving grid resiliency when grid stressing incidents occur. It's hard to imagine what the grid will look like in the next ten years. Initially experts predicted networks of BTM-DERs would force bidirectional power flows coming from the distribution network, and that has happened, but it hasn't stopped there.

The next step is focused on decentralizing the power delivery system to put the power where is it consumed, making grids more resilient to failures. Regulatory support has set the stage for that step and utilities are working with aggregators to make it happen. VPPs are already providing the ancillary services associated with large, centralized power plants helping to maintain grid stability with frequency regulation, voltage control, load following, and loss compensation to name a few. The perception of VPPs is changing for the better and VPPs are consequently improving the grid! TDW

Round Rock north of Austin, Texas, after a foot of snow fell during Winter Storm Uri. During the storm, many people were out of power for four days, with freezing temperatures persisting for six days.

Texas' Big Freeze:

Lessons Learned One Year Later

What has changed in the Lone Star State since the lethal Winter Storm Uri struck? Are recent improvements enough to keep the grid humming through a similar disaster?

By **JEFF POSTELWAIT**, Senior Editor

Texas occupies a unique spot in energy. The nation's largest energy producer, Texas makes more wind power than any other state and produces more natural gas and oil than any other state. At the same time, Texans consume more energy than residents of any other state in the U.S. — a nation already among the most electricity-hungry in the world.

There is a lot of state pride tied up in being a big player on the energy stage for Texas, so when that system fails, Texas feels the need to save face.

In February 2021, Winter Storm Uri hit North America and nearly 10 million people lost power. The wintry blast hit particularly hard in Texas, where a massive power failure led to water, food and heat shortages.

This was an unprecedented storm in many ways, but it echoes the 2011 Groundhog Day blizzard when rolling blackouts hit three quarters of Texas for several days. In both cases, freezing temperatures triggered a wide-ranging failure of the energy system. Power plants shut down in the cold, natural gas wellheads froze, fuel ran out and the loss of power crippled water and transportation infrastructure.

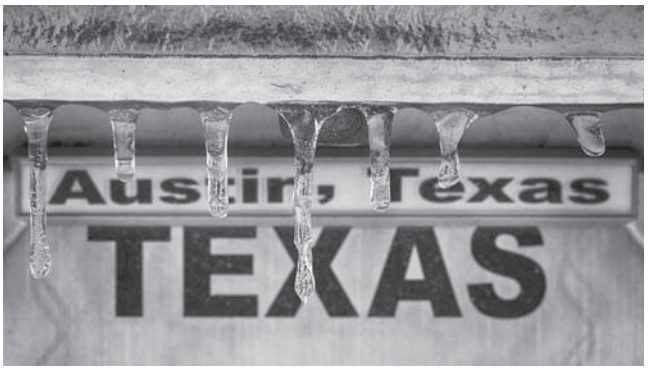
How has Texas reacted in the year since?

One change was the dismissal of two of the state's most powerful energy regulators. The Electric Reliability Council of Texas fired its CEO Bill Magness and two days before, the head of the Texas Public Utility Commission DeAnn Walker resigned following a call for change by Lt. Gov. Dan Patrick, who said ERCOT and the PUCT had "hoped for the best instead of planning for the worst."

Brad Jones, interim president and CEO at ERCOT since May 2021 said Texas' unique regulatory situation and energy ecosystem make rapid change possible.

"As a state, we were able to quickly mobilize, pass two comprehensive laws and a half-dozen state regulatory proceedings before federal authorities even completed their analysis (the report was issued in November). If we did not have our unique regulatory position, we would have lost nearly an entire year to make much-needed changes," Jones wrote to *T&D World*.

For the decades since the Texas grid has been deregulated, Jones said, the emphasis has always been on providing affordable and clean energy, but not as much on reliability. The February storm requires Texas to invest in reliability, Jones said.



Austin, Texas was one metro area that saw extended periods of no power following Winter Storm Uri. Photo by Gsphotography, Dreamstime

Extreme cold hits one of El Paso Electric's power generating units during the 2011 winter storm. The utility says this storm led it to harden its assets against future freezes. Photo by El Paso Electric

During the storm, natural gas production was interrupted by wellheads becoming frozen or having mechanical failures caused by cold weather. Texas generates nearly 45% of its electricity from natural gas. Photo by Getty Images

"We've made tremendous progress in a short amount of time. We have already completed more than 45 of the 60 initiatives on [*ERCOT's Roadmap to Improving Grid Reliability*, presented in July 2021] and we are making great progress on the remaining items. I'm proud of the work that ERCOT has done. Importantly, I see that we are working more closely with the Public Utility Commission than at any time in the past. That sort of coordination and cooperation is vital to having a healthy grid in the future," Jones said.

Texas can enter the winter of 2022 confident that its fleet of power plants is more prepared than at any time in the past 20 years for winter storms and that all market participants — generators, transmission providers and ERCOT — will ensure that there will not be a repeat of the February 2021 storm, Jones said.

A power plant in Entergy Texas service territory is shown with icicles due to the severely cold temperatures in the region. Courtesy of Entergy/Flickr.

Protecting the Grid

Despite past warnings and reminders by FERC and NERC, that generating units needed to prepare for coming winters, and despite the detailed instructions the agencies sent about winterization, 49 generating units in Southwest Power Pool (15%, 1,944 MW of nameplate capacity), 26 in ERCOT (7% 3,675 MW), and three units in Midcontinent Independent System Operator South (4% 854 MW), still lacked winterization plans, and 81% of the freeze-related generating unit outages occurred at temperatures above the unit's stated ambient design temperature. Generating units that experienced freeze-related outages above the unit's stated ambient design temperature represented about 63,000 MW of nameplate capacity.

The team behind the joint report now recommend mandatory reliability standards to require, among other things, for power plant owners to protect cold sensitive equipment; retrofit existing and future units; do annual winterization training; write action plans for freeze-related outages; and account for the effects of climate when providing data.

At a press conference Dec. 8, new PUCT Chairman Peter Lake listed out the changes his commission had made, saying the Texas grid is stronger and more reliable than ever.

ERCOT's final seasonal assessment of resource adequacy for the 2021-2022 winter said there will be sufficient installed generating capacity to serve forecast peak demand (62,001 MW) assuming "typical winter grid conditions"

Lake said the scenarios run by NERC used to write their report that found that another extreme event like the one that hit in

February 2021 would threaten power grid reliability did not account for changes Texas has made to its power grid since Winter Storm Uri.

"It's hard to understate how much reform we have implemented in such a short amount of time, but when you look at all of that and you look at the realities on the ground in front of us, yes, we can say the lights are going to stay on," Lake told the press.

Wesley J. Oliphant, principal and chief technical officer at Exo Group and a veteran of the Texas transmission and utilities market, said there is a problem with basing forecasts on what the weather typically does, however.

"Unfortunately, in my view there is a tendency to forecast the future based on events of the past. All of the wind and ice maps we use are based on historical weather events — statistical mean recurrence intervals of an event reoccurring at some point in the future. Rarely is a potentially more severe weather event taken into consideration," Oliphant said.

Texas is an energy producing state, but freezing weather has caused problems for power plants and natural gas infrastructure over the past decade. Photo by Getty Images

It's a tough sell to ask PUCs and ratepayers to pay to prepare for an event that is, by definition, statistically unlikely to happen, he said, adding that Winter Storm Uri was unprecedented in several ways.

"For Texas, it was unprecedented in both duration and how much of the state was affected at the same time. Temperature wise, several earlier winter storms actually had lower temps, they just didn't last as long or affect as much of Texas," Oliphant said.

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A high voltage substation in Texas. Because of the storm knocking power plants offline, ERCOT reported that the Texas power grid was minutes or seconds away from collapse before partial shutdowns were ordered. Photo by Getty Images

The weather was underestimated, but how interdependent Texas' various energy networks, from natural gas infrastructure to power plants to water, were underestimated too, Oliphant said.

"There is little doubt that natural gas issues were a large part of this event in Texas. However, a bigger problem was that there appears to have been a significant 'sloppiness' in coordinating and identifying (pre-event) critical natural gas infrastructure that depended on electrical power to operate the wells," Oliphant said. "With a vocal political outcry for moving toward zero carbon emissions and increasing the renewables portfolios, the delicate interdependency between natural gas and electric power generation is tenuous."

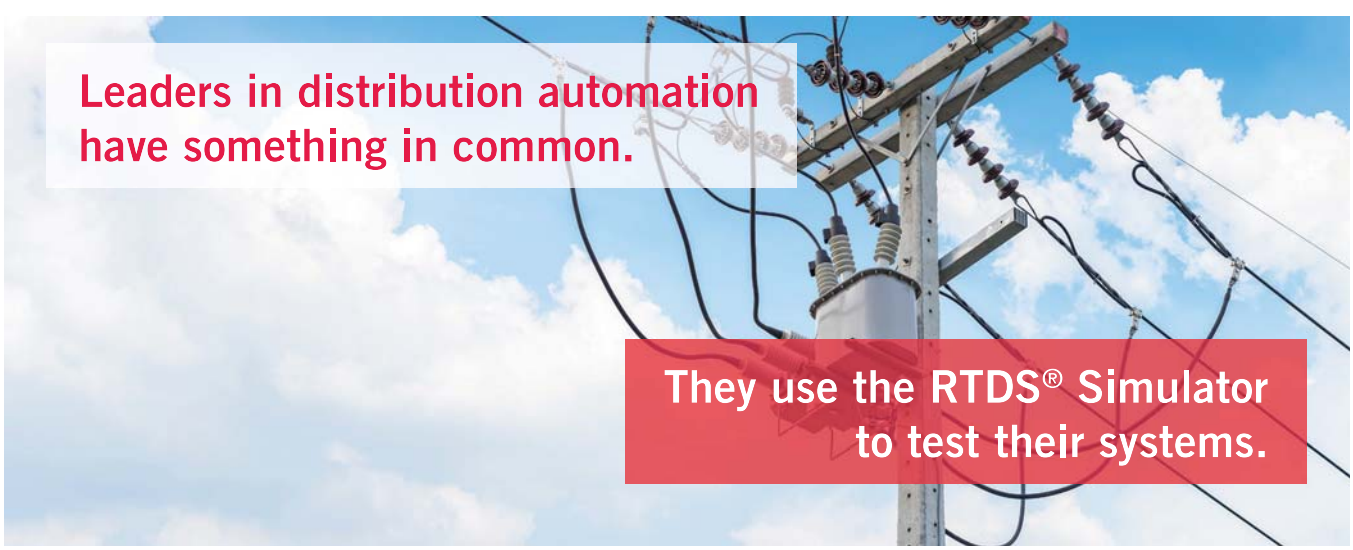
Changes for Power Plants

At the Dec. 8 press conference, Lake said the PUCT, ERCOT and the natural gas and power generation industries are working together as never before.

"Most importantly, for the first time ever we are requiring winterization for power plants in Texas. This rule was passed over a month ago and it will require power plants to have been winterized by Dec.1, attest to ERCOT that they are winterized and above and beyond that, ERCOT will be conducting inspections to confirm that our power plant fleet is winterized for this winter," Lake said at the press conference.

Lake said ERCOT would be starting those inspections soon, and referred to Jones, to address that process.

"In fact, those weatherization processes have already begun. On December 1 we received attestations from CEOs of generators



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Texas natural gas combined cycle power plant. The Texas PUC has enacted penalties for power plants that do not winterize and are inspecting plants to ensure weatherization upgrades are installed. Photo by Getty Images

and transmission service providers throughout the industry, throughout Texas that attested to us that they were prepared for the winter," Jones said.

More than 300 generating units from more than 21 owners will be inspected. Those generating units represent about 85% of the lost megawatt hours during Winter Storm Uri, Jones said. At the time of the press conference, Jones also said two transmission service providers had also been inspected, and of the roughly 54 transmission companies ERCOT expected to receive attestations from, it received 100% of those.

The PUC increased penalties for violations of winterization standards to up to US$1 million per day, per incident, Lake said. The majority of Texas' generator fleet have been "proactive" in winterizing, Lake said, adding that those who were not will be punished swiftly and heavily.

The same day as the press conference, the PUC filed violation reports against eight generation companies for failure to file winter weather readiness reports by the Dec. 1 deadline. Out of the 850 generation resources in the state, the PUCT identified 13 generation resources (representing 801 MW) owned by eight companies that missed the deadline. Companies in violation have 20 days to respond to the notice and can request a hearing.

Texas' new rules for weatherization are based on a generator best practices report from Quanta Technology first submitted in 2012, and transmission best practices recommended in 2011 by FERC and NERC. The latter was prepared following the Groundhog Day event of February 2011.

"We go into this winter knowing that because of all these efforts, the lights will stay on," Lake said at the press conference. "No other power grid has made as remarkable changes in such a short amount of time as we have, and we will continue to improve our grid and our market."

Writing to *T&D World*, Jones said nearly all the generators operating in Texas realized points of failure due to the February storm.

Texas regulators are for the first time ever requiring winterization for power plants. Over 300 generating units from more than 21 owners will be inspected, according to ERCOT. Photo by Getty Images

"They began immediately to have their teams identify the steps they needed to complete to be better prepared for the next winter. I know that tens of millions of dollars were invested by just three generators to winterize their equipment for the winter of 2022. They began this work BEFORE there was any type of regulatory

Q&A with El Paso Electric

El Paso Electric is a public utility company serving 450,000 customers with its service territory in Southern New Mexico and West Texas. Load centers include Las Cruces and El Paso. *T&D World* spoke with Steve Buraczyk, Senior Vice President of Operations with EPE, on the changes his utility enacted after the 2011 winter storm.

T&D World: *In 2021, El Paso Electric fell outside the area of the rolling blackouts. Is this just luck, or were there some measures taken since 2011?*

Buraczyk: EPE is a vertically integrated, regulated utility that is interconnected to the Western Electricity Coordinating Council (WECC) — one of three major electric grids in the United States. Although EPE is not interconnected to ERCOT, which was severely hit by both the February 2011 and 2021 cold snaps, the ripple effect felt beyond ERCOT was undeniable. The impact on fuel resources alone could have impacted EPE's reliability but the decision to invest in new generation with dual-fuel capability provided a layer of protection to our customers that many others in the state do not have.

Construction at El Paso Electric's natural gas-fired Montana Power Station. The station was upgraded after a 2011 cold weather event to have quick-start capability for better power grid stability. Photo by El Paso Electric

T&D World: *How would you compare and contrast the 2021 event with the one that happened ten years ago?*

Buraczyk: The cold snap that hit Texas in February 2011 was strikingly similar to the one that hit this year in February – same timeframe and same freezing temperatures. The only stark difference was EPE's preparation for the 2021 cold snap based on lessons learned 10 years ago. The freezing temperatures did not last as long in 2021 for the West Texas/El Paso area as it did for the rest of Texas, but the ripple effect was still felt here, especially access to natural gas to fuel power generation stations.

T&D World: *After the 2011 event, what were the findings and recommendations? What came of those, if anything?*

Buraczyk: Multiple lessons were learned from the 2011 event. A foundational change that came from 2011 was how EPE hardens its infrastructure for extreme winter weather events, such as changing the generation design threshold to -10 degree-Fahrenheit at its local generation plants. Also, recognizing that the natural gas supply can be interrupted, regardless of firm commitments, the importance of having dual-fuel capable units that can be started on and run using 100% fuel oil.

T&D World: *What are the challenges Texas faces with winterizing? Is it possible to prepare for severely hot and severely cold weather?*

Buraczyk: our typical extreme occurs during the summer months when triple-digit weather is common. However, during the winter season we need to be prepared for those brief but crucial periods of freezing temperatures. Recognizing the need to improve after our 2011 event EPE has:

- Invested approximately $4.5 million on winterization upgrades at its local power plants designed to enable operations of the generation fleet down to -10 degree-Fahrenheit.
- Diversified EPE's generation mix since 2011. EPE has added 352 MW of quick start combustion turbine generation at its new Montana Power Station (MPS) that had a design temperature down to -10 degree-F.
- Designed MPS with dual-fuel capability to guard against natural gas supply disruptions. During the 2021 event EPE relied on the dual-fuel capability at MPS due to natural gas curtailments that were seen throughout Texas and New Mexico.
- Identified critical load customers – they are now documented and tracked so that if interruptions are needed to preserve the bulk electric system, customers that are needed for the health, safety and welfare of the communities we serve are spared when possible.

T&D World: *Does El Paso Electric plan any further weather hardening measures, or are some under way at the moment?*

Buraczyk: One key point is that the winterization investment made after 2011 need to be maintained. This requires testing and replacement of those systems as needed. EPE does this every year to ensure the systems are performing as designed and the insulation at its plants had not degraded. While EPE's generation fleet performed well in 2021, there were small challenges that EPE learned from. As a result, EPE has added additional protection in areas at its local generation plants that did have minor impacts, real world conditions did identify where freeze protection could be improved and added to our winterization checklists. EPE has also implemented freeze protection specific training for its power plant employees to ensure that new employees understand what is needed to maintain generation reliability in freezing conditions.

Additionally, in December 2021, EPE completed its Blackstart Project at MPS. The new capability will allow the units at MPS to be started and synced to the grid through a backup diesel generator. This means EPE will be able to initiate a restoration plan and restore power to our region in the event of a system-wide blackout. The Blackstart capability is just another way EPE is making efforts to provide additional reliability to its customers.

framework laid out; they did it because they knew there could not be a repeat of February 2021," Jones wrote.

Robert Kondziolka, governing body member for the Western Energy Imbalance Market, former transmission director with the Salt River Project and former engineer for Tucson Electric Power, said after the 2011 cold weather event that disrupted the ERCOT, WECC, MISO and SERC regions, WECC led an effort in the Western Interconnection to address all the recommendations from the FERC-NERC report.

"WECC tracked the progress by each entity in getting the recommendations implemented. At the state level, the Arizona Corporation Commission required improvements by the natural gas supplier to prevent low pressure to residential users should another similar event occur," Kondziolka said.

El Paso Electric, which lies outside ERCOT, is an example of how progress was made well before the 2021 freeze, Kondziolka said. After seeing what cold weather could do to power plants, El Paso Electric made the recommended improvements to its local gas-fired generation fleet so they would be reliable during another extreme cold weather event. During the 2021 event its local generators operated reliably, and it did not need to implement load curtailments to meet their system demand, Kondziolka said.

"It does appear to me that both the Texas PUC and ERCOT are at least saying the right things," Oliphant said, but cautioned that major improvements will not happen overnight and must address a wide-ranging, complicated set of problems.

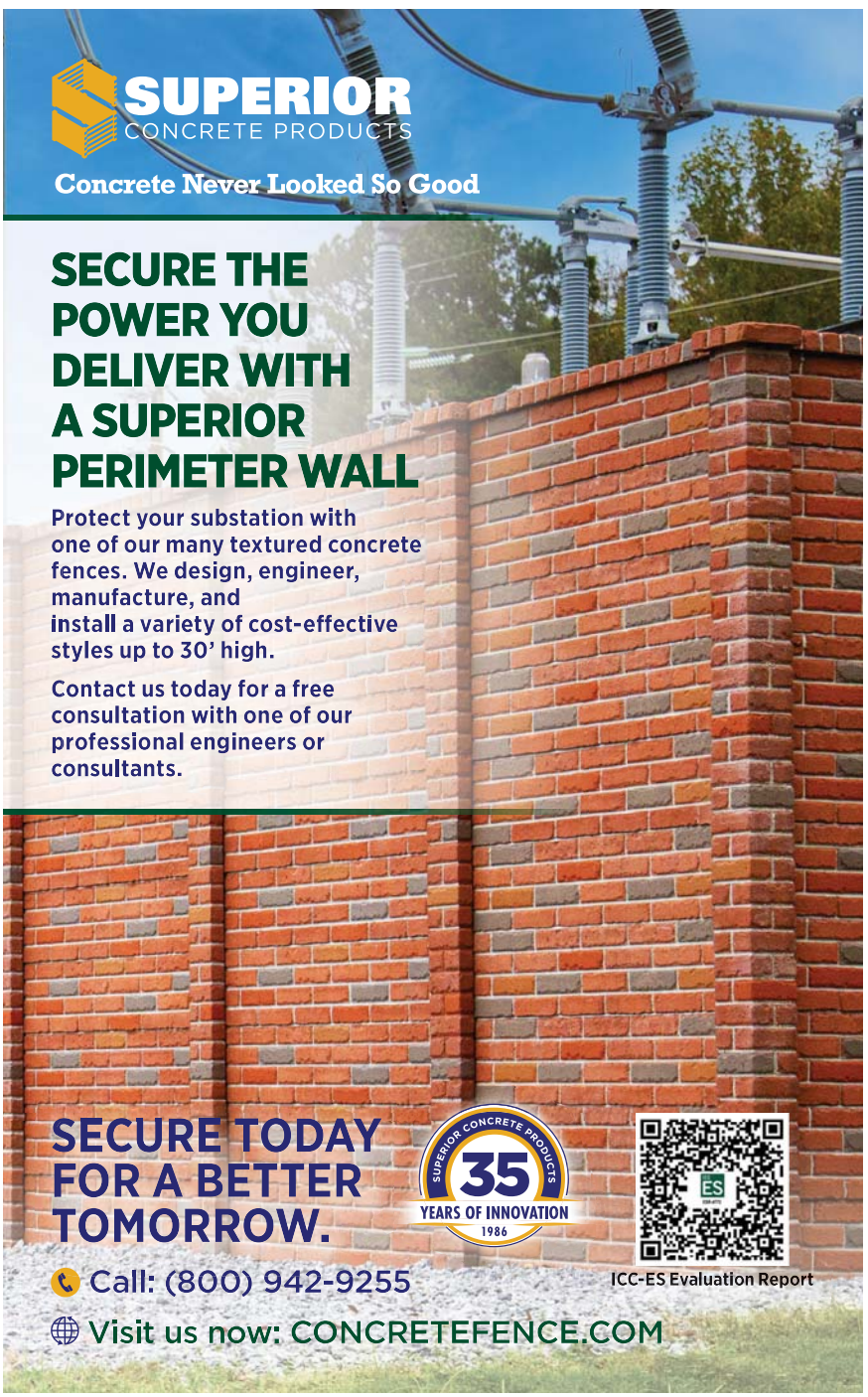
A more robust reliability culture, a smarter load shed methodology, and evaluating what can be gained with more grid interconnectivity between the Eastern, Western, and the ERCOT grid could each be helpful, Oliphant said.

"The wires side I think has a good embrace of [resiliency culture] already, but the generation side, at least here in Texas, has lacked market or other incentives to promote that type of culture. And doing so because it is the right thing to do just may not work," Oliphant said.

Interconnections

As the news covered the aftermath of Winter Storm Uri and words like "ERCOT" and "interconnection" started being used by laypeople around the country, the links between the Texas power grid and other regional grids got talked about quite a bit. The map of the North American grid interconnections, to people who have never seen it and do not know the history, does look a little odd with the Western Interconnection covering half the continent, the Eastern Interconnection covering the other half, and then that strange Texas-shaped chunk taken out of the middle.

ERCOT operates as a functionally separate interconnection, although it has four asynchronous ties with other interconnections: Two direct current (DC) transmission tie lines between ERCOT and the Eastern Interconnection through SPP: the North Tie, and the East Tie. There is also a pair of ties between ERCOT and Mexico. ERCOT does not have any synchronous connections to the Eastern Interconnection, Western Interconnection, or Mexican grid.



Austin Suburbs covered in snow after dangerous and deadly winter storm Uri leaves Texas without power and in the cold Feb.19, 2021. Photo by Getty Images.

ERCOT's counterparts to the north and northeast, the Southwest Power Pool and the Midcontinent ISO, have strong networks of transmission tie-ins at different voltage levels.

In FERC and NERC's recommendations, the agencies write ERCOT "should conduct a study to evaluate the benefits of additional links between the ERCOT Interconnection and other interconnections that could provide additional reliability benefits," which include increased ability to import power when its system is stressed during emergencies and improved black start capabilities. The agencies encouraged ERCOT to perform these studies as soon as possible.

The recommendation suggests the possibility that, in a similar event, ERCOT may not be able to facilitate a re-start of the grid given the combined unavailability of black start and natural gas-fired generating units. Having access to additional imports could be critical, according to FERC and NERC, if ERCOT experienced a blackout and had multiple black start generating units outaged, as was the case during the February 2021.

When asked about the reliability benefits of further interconnections, Jones said the February 2021 storm was so severe and wide-ranging that more interconnections would not have helped.

"ERCOT would not have benefitted from interconnecting further with other grids and the facts, as outlined in the Federal Energy Regulatory Commission (FERC) and our own data, back that up. FERC identified that the grids closest to ERCOT did not have power to send to Texas during the February winter storm. Our own data, from imports at our DC ties, show that as the storm worsened, imports were cut. Additional interconnection would not have helped because there was no power to send," Jones wrote to *T&D World*.

Jones added that more interconnections could cost millions if not billions of dollars, and that money would be better spent on ERCOT's own infrastructure to achieve reliability results higher than what could be had from an interconnection.

In one example, Jones said Texas' Rio Grande Valley contains several stranded generation assets that could help serve the rest of the state if transmission congestion issues were addressed.

"Improving service to the lower Rio Grande Valley has been a key initiative for ERCOT. At its core, the transmission constraints represent unfair service levels to the people and businesses in the Rio Grande Valley. At a higher level, those constraints create grid management challenges that shouldn't exist for ERCOT. The PUC last week gave the approval to begin the multi-year process to resolve those constraints," Jones said.

Kondziolka said that while he lacks the perspective of ERCOT's system operators, FERC and NERC are right to suggest a look at interconnection benefits.

"If ERCOT had better interconnections with adjacent regions they likely never get to the low point they did," Kondziolka said. "When they initially started losing generators, they could have relied on emergency assistance from adjacent regions (prior to energy being as scarce as it got). This may have provided time for ERCOT to figure out why they were inadvertently dropping circuits that provided service to generators and prevented them from operating."

Doing this would allow more natural gas to stay or get into the system, help moderate prices and increase gas generation availability outside of Texas. This, in turn, would provide for more energy assistance across North America.

"It doesn't necessarily decease load but could provide time to help implement conservation measures. The only way you would know if increased interconnections would help is to start the analysis at the beginning or just prior to the event and model those conditions and work through it step-by-step. A lifeline at the beginning when needs are small provides much more value than a lifeline when needs are big," Kondziolka said.

More Winters are Coming

"The devastating effects of extreme cold on our bulk power system's ability to operate in 2011 and now, 2021, must not be allowed to happen again. We have a duty to protect the bulk power system and public safety and we will do just that," Rich Glick, Biden's chairman of FERC said in his commission's final report on the February 2021 freeze.

FERC and NERC's joint recommendations found that protecting just four types of power plant components from icing and freezing could have reduced outages by 67% in the ERCOT region, 47% in the SPP and 55% in the MISO South regions.

The failure of the Texas grid had mostly to do with power plants and the natural gas infrastructure that feeds plants and heats homes both freezing. Eighty-one percent of the generating units that went offline did so at temperatures above the units' stated temperature limits. Of the power plant outages that happened because of an interruption in fuel supply, 87% of these were at natural gas-fired power plants.

According to NERC, this was the largest firm load shed event in U.S. history, at 23,418 MW, and the third largest in quantity of outaged megawatts of load, with only the August 2003 and August 1996 blackouts being worse.

The two agencies and their partner organizations said Texas is locked in a "recurring pattern for the last 10 years" where extreme weather makes power plants unable to produce power, leading to a power crisis. TDW

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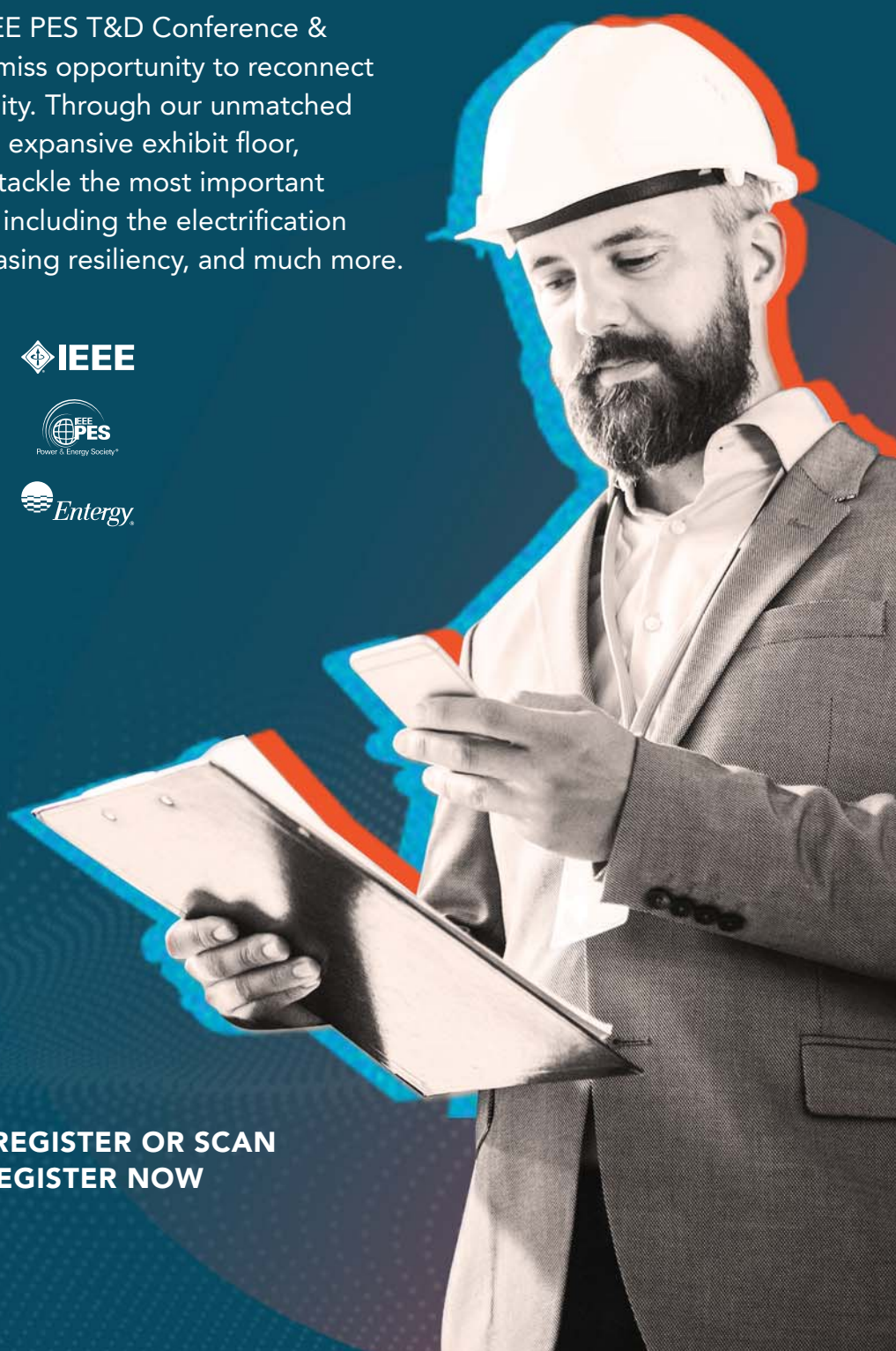

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Without SEAPA's subsea transmission connection to the mainland, several Alaska island communities would be entirely dependent on diesel generators for power. Photo by SEAPA

An Alaskan High-Voltage Submarine Cable Failure

A utility serving several isolated Alaskan communities works to repair a severed power lifeline to the mainland.

By **ROBERT SIEDMAN**, Southeast Alaska Power Agency

When communities on remote islands are connected to an interconnected power system, the reliability of supply gets a boost while customer energy costs are reduced. For the small island of Petersburg, Alaska, U.S., the electrical connection to the Southeast Alaska Power Agency's (SEAPA) power system reduces customer energy costs by more than 70%. Without SEAPA's carbon-free connection, Petersburg would be forced to rely on diesel generation that, on average, discharges some 92,250 lb (41,844 kg) of CO_2 annually.

In September 2019, one of SEAPA's four, single-phase 138-kV oil-filled submarine cables failed. It was lying at a depth of 700 ft (213 m) at the bottom of the Stikine Strait crossing between the two uninhabited islands of Woronkofski and Vank. The potential cause of failure was an underwater avalanche-like landslide that separated the cable. Installed in 1984, these high-voltage (HV) subsea cables form part of SEAPA's 175-mile (282-km) transmission system, which connects the communities of Petersburg, Wrangell and Ketchikan, Alaska, to the utility's hydro-generation facilities.

SEAPA has four submarine cable crossings, each consisting of four single-phase cables totaling more than 55 miles (86 km). Three of the four cables in each crossing are energized continuously, with the fourth cable — a spare — deenergized at any given time. Every year, SEAPA rotates the energized cables to ensure their integrity, resulting in one cable remaining deenergized for no longer than one year at a time.

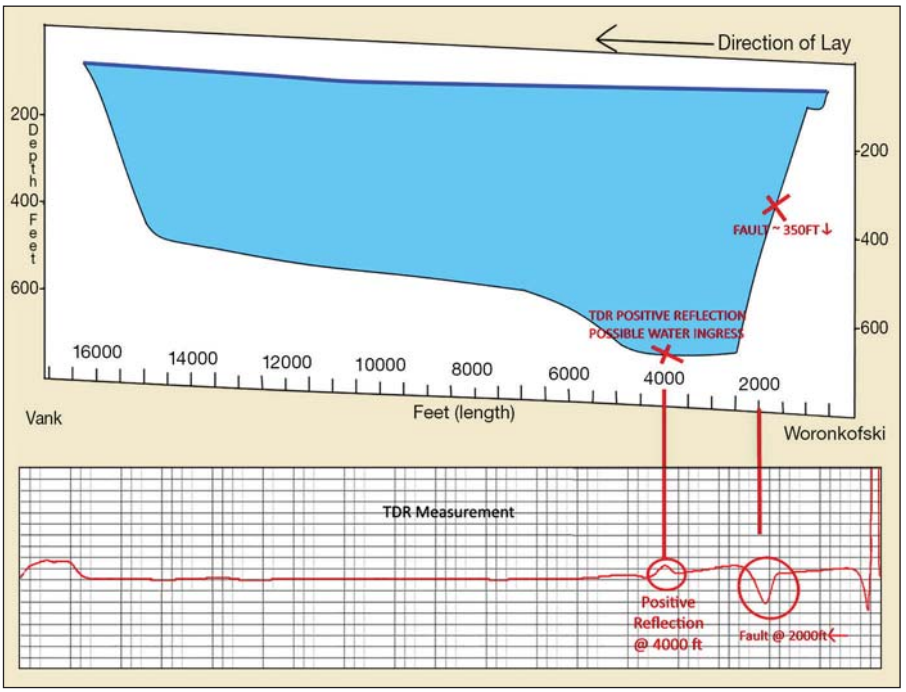
Following the energization of the previously deenergized (spare) cable, the three-phase power supply to Petersburg was restored, but with an elevated risk to the security of that supply. Failure of any of the remaining single-phase cables would result in Petersburg having to resort back to diesel generation, with an energy cost up to four times the average. To avoid this scenario, a project was initiated to repair or replace the faulted HV cable with minimal delay.

Fault Investigation

Before considering cable replacement, SEAPA investigated the possibility of performing a splice to effectively repair the failed cable. Time-domain reflectometer (TDR) tests were performed

to identify the position of the fault. Test results signaled a negative reflection, indicating a break in the cable at nearly 2000 ft (610 m) offshore at a depth of 350 ft (107 m). A smaller positive reflection also was evident, which was either a possible ghost reflection or water ingress from gravity and density differentials between the seawater and oil.

Remotely operated vehicle (ROV) footage revealed the failed cable was severed and that water ingress was highly probable at the point of failure to the deepest part of the cable. Although SEAPA had 2000 feet of oil-filled cable in storage, when considering the probability of water ingress over a cable length greater than 2000 ft, the agency concluded it was not possible to repair the cable.



Cable 1 with TDR. Graphic by SEAPA.

A Replacement Cable

Subsequently, specifications for a new replacement cable were developed, and SEAPA launched a request for proposals (RFP) with the support of a submarine cable consultant, Center Marine Services Inc. The replacement cable contract was awarded to Sumitomo Electric Industries Ltd. through a competitive evaluation bid process. SEAPA selected the company because of its reliable track record of more than 100 years of submarine cable manufacturing experience and sound proposal based on extensive knowledge of the U.S.

SEAPA engineering and eTrac Inc. gathered and provided an arsenal of information to Sumitomo:

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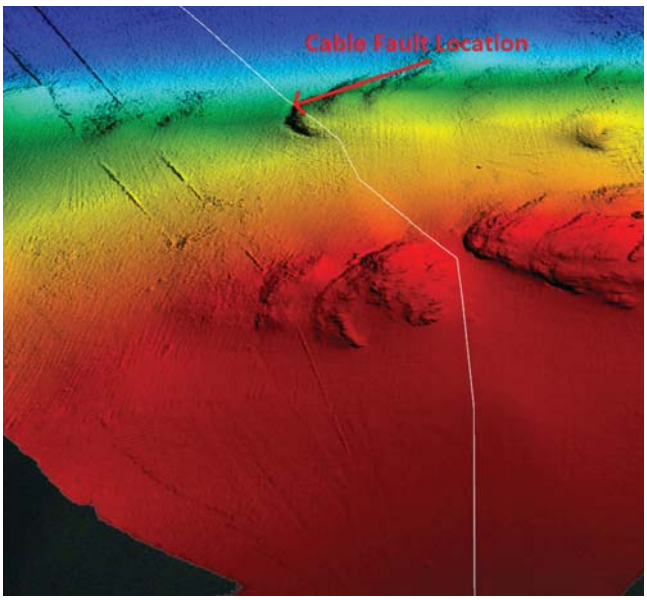

High-Resolution multi-beam sonar bathymetric map. Photo by eTrac Inc.

- ROV footage.
- High-resolution multi-beam sonar bathymetric maps.
- Magnetometer sub-bottom profiles.
- Directional peak cable location surveys.

Using SEAPA-furnished surveys, Sumitomo began the design process for the replacement cable in November 2020.

Design Phase

The SEAPA transmission system for Petersburg was designed and installed with 138-kV submarine cables to supply a potential 200% increase in load growth. However, since its commissioning in 1984, this transmission system has remained in operation at 69 kV. Therefore, SEAPA specified a 69-kV cable instead of a 138-kV cable to reduce costs while still maintaining a sufficient 100% increase in load-transfer capacity for future growth. The decision to reduce the voltage requirement also reduced the following:

- Total cable weight
- Challenges associated with transportation logistics
- Time for cable installation

To satisfy SEAPA specifications, Sumitomo designed a double-armored 69 kV XLPE insulated submarine cable with integral fiber optics that would sustain a pressure of 315 psi at a water depth of 700 ft (213 m). A continuous 17,400-ft (5, 304-m) length of cable was manufactured with no factory splices. Ancillary equipment required to perform potential future repairs had to meet similar demanding pressure requirements.

Along with the new cable, Sumitomo designed a dual-purpose cable storage turntable system to transport the cable from Japan to Alaska and store the recovered existing oil-filled cable prior to installation of the new cable. The design included oil containment for potential escapement due to temperature-related pressure changes in the existing cable that had to be recovered from the subsea floor.

Aerial Footage of Wrangell Alaska during Installation Phase. Photo by SEAPA

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Cable Removal Phase

Sumitomo subcontracted the cable installation and cable removal phases of the contract to ITB Subsea Ltd. (ITBS). The 17,400-ft (5304-m) cable, weighing more than 600,000 lb (272,155 kg), was transported from Japan to Vancouver, British Columbia, Canada, where it was transferred to the ITBS dynamic-positioning vessel. On July 1, 2021, ITBS began the removal phase of the project.

During the oil extraction process, and governed by fluid dynamics, oil extracted on the shoreline was replaced by saltwater at the fault location 350 ft (107 m) below the ocean surface. With 140 gal (530 liter) extracted, nearly 8000 ft (2438 m) of cable was oil free. The cables were capped and hydraulically locked, ready for removal.

Installation of the 69 kV XLPE insulated cable, Vank Island, Alaska. Photos by SEAPA.

With the cable ends capped, the process for removing the cable consisted of the following:

- Pulling the shoreline ends onto the vessel, the ITB 45, using ropes and mesh pull grips.
- Using dynamic positioning, the existing cable was extracted onto the ITB 45 and loaded into the cable storage system, specifically designed to contain the cable should an oil leak occur.
- Monitoring tensions so as not to exceed the cable manufacturer's tension limits.
- Calculating fluid dynamics to determine the depth required to maintain equilibrium pressures for CanPac Marine Services Inc. divers to install caps without oil escapement.
- Deploying divers at the faulted cable ends to cap the cable underwater and prevent oil escapement.

The cable removal phase proved to be successful, with no oil released and 100% of the faulted cable removed. The total start-to-finish time of four and a half days included diving operations, ROV cable location, shoreline extractions and dynamic positioning vessel subsea extractions.

Cable Installation Phase

Removal of the existing cable may have been the riskiest operation of the project, but installation of the new cable proved to be the most challenging. Southeast Alaska has tidal exchanges of more than 20 ft (6 m), with some of the most extreme riptides and tidal currents in the world. Located within the Alexander Archipelago, Vank and Woronkofski Islands have steep shorelines, no access roads and volcanic rigid rock formations under the water surface.

Precise routing plans with precision routing equipment was required for this phase of the project to be successful. Although it was preferred the cable be laid completely on the subsea floor, cable spans were allowed but had to be less than 20 ft in length, with the cable laid entirely within the existing permitted right-of-way. Rock outcrops, boulder fields, cliffs and steep slopes had to be avoided as well as sharp changes in the seabed profile.

Installation was planned to happen during the lowest tidal exchange in the month of July to minimize the effects of tidal currents while the cable was being laid at a depth of 700 ft (213 m) below the water surface. Coincidentally, this window of opportunity occurred on July 4, 2021. While the residents of Wrangell were enjoying Independence Day festivities, SEAPA, Sumitomo and subcontractors were diligently performing operations to successfully install the new submarine cable during the small window of low tidal exchange. The results of this installation phase were exactly as engineers planned.

Failure Turned Success

With little wind, bluebird sunny skies and minimal tidal currents, the new subsea cable was installed from shore to shore

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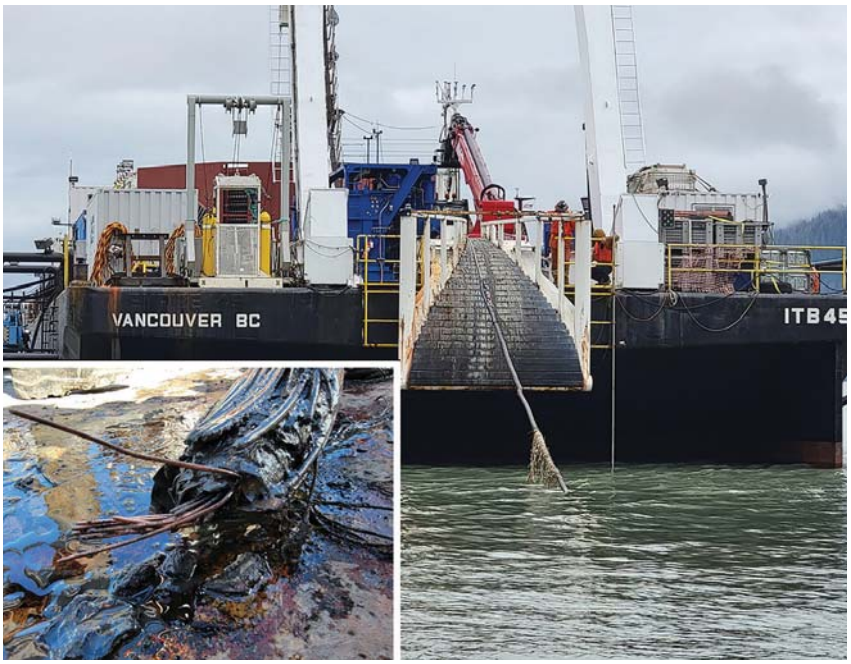

Removal of the oil-filled submarine cable near Wrangell, Alaska. Photo by SEAPA.

without incident. An underwater ROV was deployed during operations to confirm the approved cable route and specifications were met. The result was the 3.3-mile (5.3-km) subsea cable was installed with only two short sections suspended less than 6 inches (152 mm) above the seabed and spanning less than 15 ft.

Partial-discharge testing was used to confirm a successful installation project undertaken by Sumitomo, ITBS, Westpark Electric Ltd. and all the participating subcontractors. The collaborative efforts of all parties turned SEAPA's Alaskan island-to-island subsea HV cable failure into an island-to-island success story. TDW

ROBERT SIEDMAN (*rsiedman@seapahydro.org*), P.E., graduated cum laude from Washington State University with a bachelor's degree in electrical power engineering and joined the Schweitzer Engineering Laboratories Inc. He expanded his experience at the U.S. Army Corps of Engineers (USACE), where he held the position of chief of power systems for the USACE Hydroelectric Design Center. Following more than 15 years of power-related experience, Siedman joined the Southeast Alaska Power Agency (SEAPA) in 2017 and currently serves as director of engineering and technical services.

For More Information

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Hydro-Quebec's Chomedey Station Laval. Hydro-Quebec is a public utility that manages the generation, transmission and distribution of electricity in the Canadian province of Quebec, as well as the export of power to portions of the Northeast United States. Photo by Michel Bussieres Dreamstime.

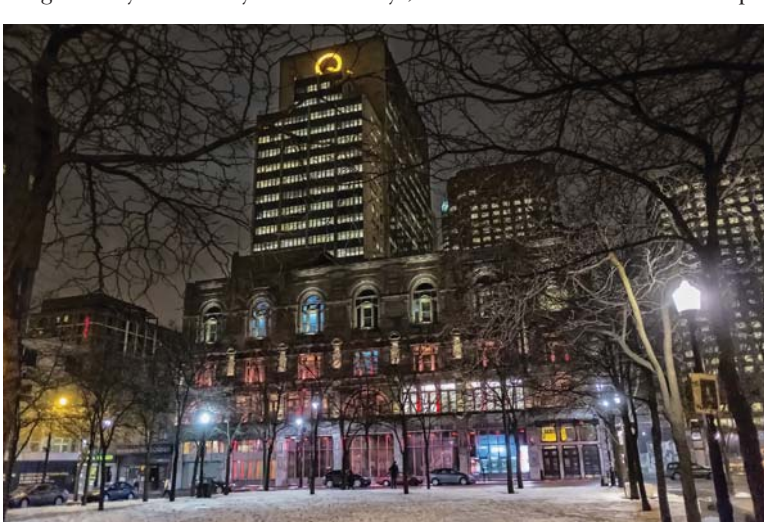
New Life for Underground

Hydro-Quebec addresses maintenance challenges of underground cables with new program.

By **MICHEL TRÉPANIER**, **CLAUDE TREMBLAY**, and **LIONEL REYNAUD**, Hydro-Quebec; and **MATHIEU LACHANCE**, OMICRON Energy

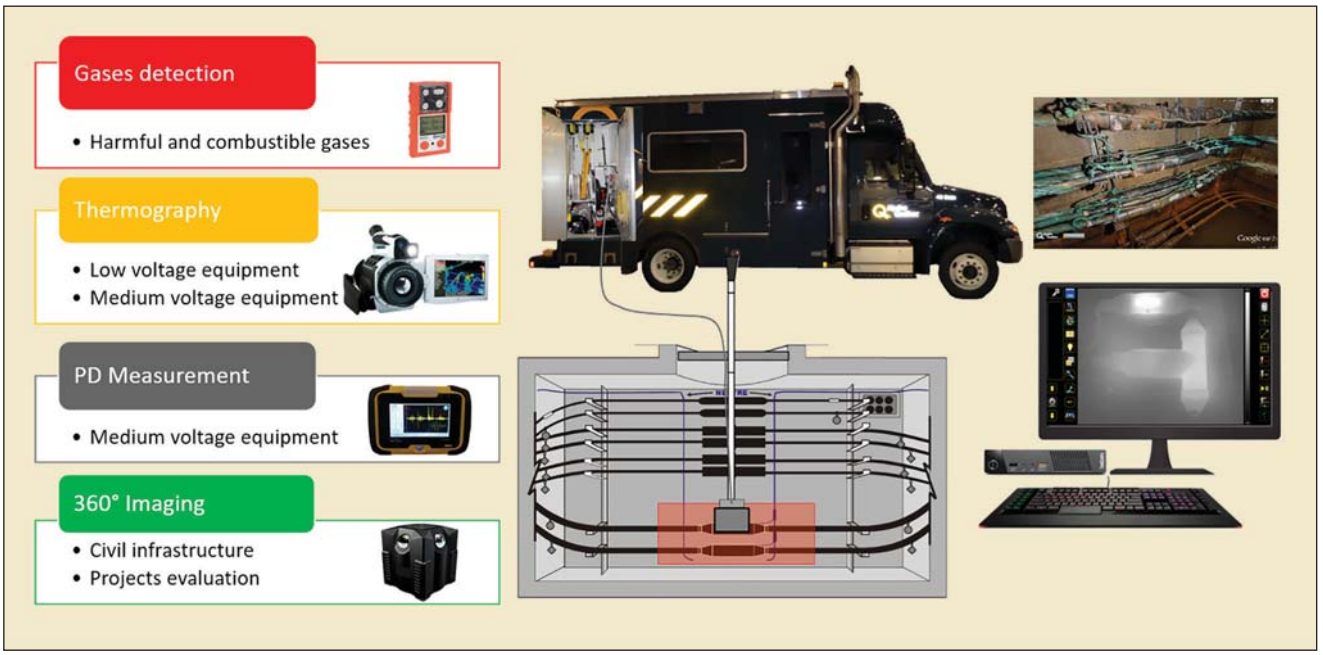
Medium-voltage underground cable systems are a critical part of the electric distribution network. Like any other power apparatus, the insulation of these underground cable systems ages over time. In North America, many underground cross-linked polyethylene (XLPE) cables were installed in the 1970s and 1980s, with a reported design life in the range of 30 years to 40 years. Nowadays, utilities are faced with underground distribution systems that are, theoretically, either at the end or past their design life.

The replacement of every piece of equipment and accessory that has reached its theoretical design service life is not an option for both economical and practical reasons. First, newly introduced technologies can lead to higher risk of infant failures. Second, each specimen ages at a different rate depending on the operating and environmental conditions. Therefore, maintenance and diagnostic tests are common practice to assess the health of critical power system assets. This can be challenging for utilities when workers or funding are not available to test every electrical component periodically.



Montreal street scene at night with Hydro-Quebec's headquarters in the background. Photo by Michel Bussieres, Dreamstime.

In 2005, Hydro-Quebec found that most in-service failures in its underground distribution network occurred at cable joints. A common cause of deterioration in these cable accessories was partial discharges (PD). Therefore, Hydro-Quebec Distribution implemented a thorough inspection procedure to decrease the rate of failure in its underground distribution network. Among other tools, a multilevel PD detection approach was adopted to minimize the need for expertise on-site. Several case examples highlight the advantages of such an inspection procedure for the underground system.



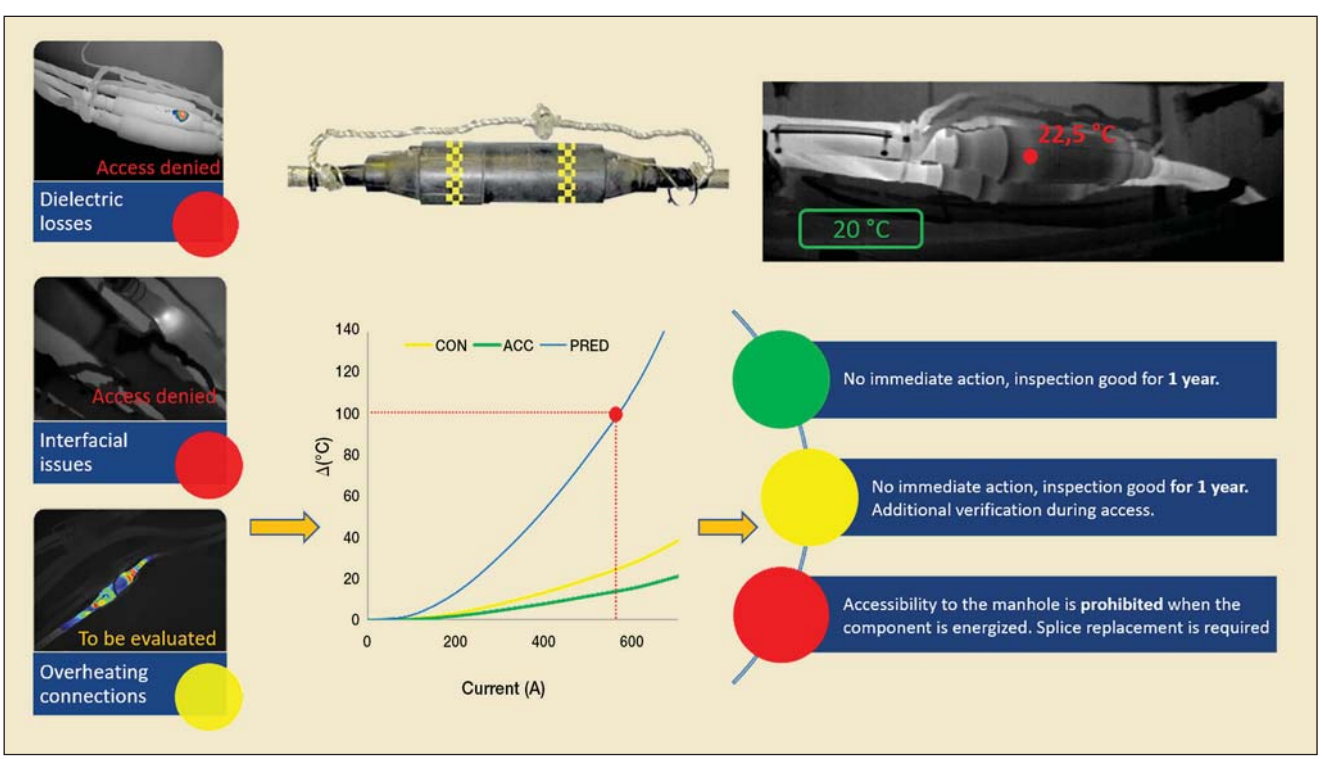
Inspection program phases. Graphic by Hydro-Quebec.

PD Theory

At a basic level, PD is a localized dielectric breakdown of a small portion of an insulation system under electrical stress. Partial discharges can occur when the local electric field exceeds the local dielectric strength at a given location, within or at the surface of an energized object.

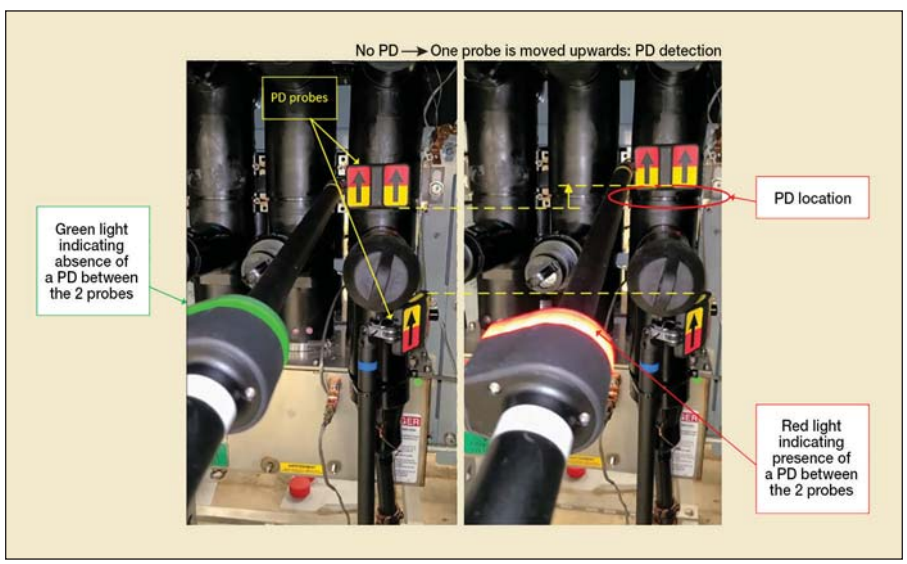
Each PD event generates a current pulse. At its origin, if the discharge occurs in atmospheric air, this pulse has a rise time of just a few nanoseconds and contains a theoretical constant broad frequency spectrum, from direct current to up to several hundred of megahertz. Therefore, PD can be detected using different technologies.

The IEC 60270 standard defines the broad lines of PD measurements in many electrical apparatuses. It specifies the test circuit, type of sensors, measured frequency range and apparent charge (in picocoulombs) as the unit to quantify PD activity. The standard is mainly applicable for PD measurements performed in controlled environments, such as in a factory or laboratory, where interferences can be mitigated easily. PD measurements that comply with IEC 60270

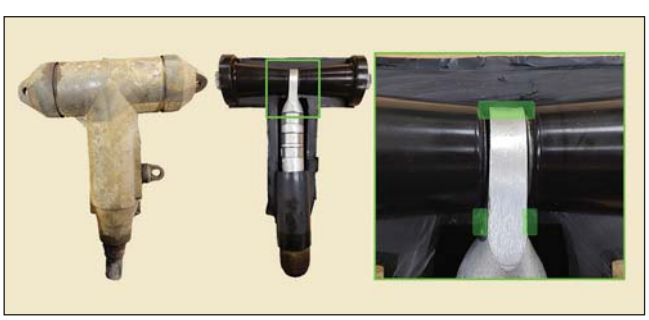


Automatic evaluation of a splice performance. Graphic by Hydro-Quebec.

PD alarm mobile unit. Graphic by Hydro-Quebec.



PD location performed with PD alarm tool. Graphic by Hydro-Quebec.



Surface contact problem with T-elbow. Graphic by Hydro-Quebec.

commonly are referred to as conventional PD measurements.

For PD measurements performed in the field, it can be challenging to comply with every requirement of IEC 60270. Space restrictions, a high level of interference and difficulties in performing a valid calibration are among the most common reasons why other techniques are used. These often are defined as unconventional PD measurements and described in IEC 62478.

An example of such measurement is the use of an antenna as a sensor. The antenna is installed on the surface or near an equipment and captures part of the energy from the electromagnetic wave generated by the discharge activity. In this case, many factors can influence the measured quantity; therefore, the assessment usually is focused on whether PD activity is detected rather than quantification of the discharges.

The Inspection Program

Hydro-Quebec has taken steps to become a leader in on-line problem detection over the years. It first started exploring the use of predictive maintenance in 1996 to make access to its underground facilities safer. Now, more than 25 years later, Hydro-Quebec has a mature and sophisticated preventive inspection program in place that makes it possible to target any potential anomaly of an accessory before a failure in service occurs. It also provides workers with safe access to underground facilities.

Every vault is inspected once every six years, and 30 teams are dedicated to conducting this inspection program. It represents an annual inspection of more than 100,000 accessories in 12,000 vaults. Every vault inspected without any anomaly is given an access validity period of one year. Along with these inspections, several hundred repairs a year must be made in vaults that do not have this period of validity and require an emergency inspection.

A vault inspection is broken down into four phases:

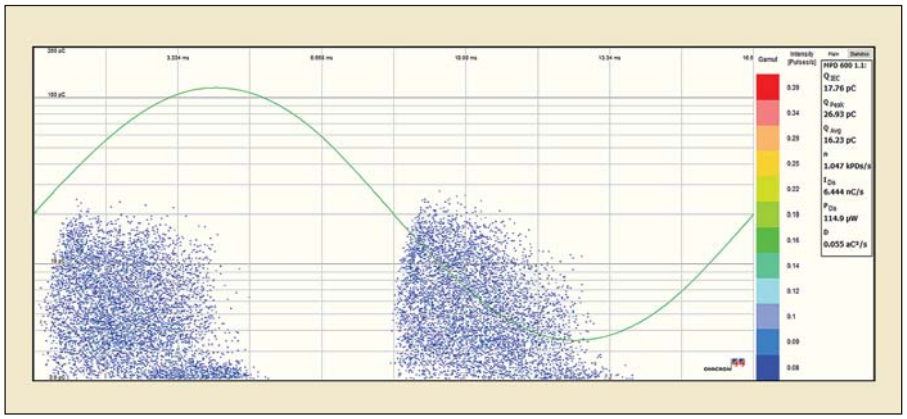
1. Measurement of potentially harmful and combustible gases.
2. Thermographic measurements of low-voltage (LV) and MV components to identify hot spots.
3. PD measurements on MV accessories.
4. 360-degree photo capture integrated into an interactive 3-D experience tool to help plan, visualize and evaluate events (a virtual tour of underground installations, optimization of work preparation, evaluation of vault degradation, new line routing with fewer field visits).

Depending on the test to be performed, infrared or 360-degree imaging, the device is fixed at the end of the pole. The pole is lowered inside the structure. The cameras are connected by cable to a computer in the thermograph truck. An operator handles the cameras, views the infrared images and detects hot spots. Hydro-Quebec has developed a diagnostic software to evaluate the performance of splice connections (that is, the internal temperature of each accessory and the current for which the maximum temperature will be reached, given the type of splice, cable size and ambient temperature).

PD measurements are complementary to the thermographic inspection. If no anomaly is detected by thermography, PD

measurement is done on all the MV components present inside the underground vault. On-line PD measurements made by Hydro-Quebec in its maintenance program are nonconventional, which means only the presence of PD in an accessory is measured, not the charge in picocoulombs.

A PD sniffer has been designed specifically by Hydro-Quebec for use by nonexpert workers as a first-level safety tool. It can recognize a PD signal in a fully automatic manner without any interpretation. Recently, the PD sniffer has been replaced gradually by a new lighter, less expensive PD alarm tool, also developed by Hydro-Quebec.



PRPD analysis of molded bus bar. Graphic by Hydro-Quebec

The PD alarm can detect the inversion of polarity of a PD produced between two antennas at a range of operation below 30 MHz and centered around 18 MHz. This low-band frequency allows much more standard and cheaper electronics for all necessary treatments than at higher frequencies. The development of antennas also is one of the keys to success.

When potential PD is detected by a thermographer, the person leaves the vault and calls the technical team of engineers for validation. An engineer then uses an advanced system, the partial discharge analyzer (PDA), to confirm or deny the presence of PD.

Case Studies

Over the years, PD measurements have enabled Hydro-Quebec to detect dielectric anomalies on not only aging underground accessories but also those newly installed in the network. This has helped to avoid worker exposure to imminent risk as well as breakdowns and associated costs by removing these problematic accessories before a failure occurs in service.

Most cases are caused by improper assembly while a minority are caused by manufacturing issues. However, manufacturing issues can have a greater negative impact on the network. Although factory tests are carried out by manufacturers of electrical distribution products, sometimes a dielectric fault is detected on the accessory installed in the network. These

latter cases are the most interesting because they are the subject of a more in-depth analysis. Following are some examples of problematic accessories that have passed manufacturers' tests and been installed in a network.

600-A Molded Bus Bar

Hydro-Quebec line workers install 600-A molded bus bars in vaults to interconnect molded fuses and transformers. They also are part of a multichannel solid dielectric switchgear deployed on the utility's network.

With the PD sniffer tool, Hydro-Quebec thermographers noticed probable PD on molded bus bars installed in vaults. An expert engineer confirmed the presence of PD with the PDA system. He also used the PD alarm tool, which indicated the presence of PD. After removal, a phase-resolved partial discharge (PRPD) analysis was done on the defective units with the OMICRON MPD 600 system. It clearly showed the presence of PD.

Almost at the same time, the engineer in charge of testing all new equipment prior to field installation measured and confirmed the PD on multichannel dielectric switchgear, also using the OMICRON MPD 600 system. Doing some open-close operations on the switchgear, the test engineer determined the PD was coming from the bus work of the apparatus but could not tell which component of the bus work was defective. To finalize his analysis, the test engineer used the PD alarm tool to locate the defective part of the bus work: a 600-A molded bus bar.

Following this event, Hydro-Quebec carried out PD measurements on new accessories from this manufacturer. This survey confirmed the presence of PD activity on a high percentage of the analyzed accessories.

Based on the PRPD analysis done on the tested molded bus bars, the test engineer suspected the PD was created by a porosity in the insulation material. X-ray images were taken on three defective molded bus bars and the verdict on all of them was the same: Porosities existed in the insulation at one end of the molded bus bar. The manufacturer analyzed and dissected the returned units, coming to the same conclusion as Hydro-Quebec. The manufacturer took corrective actions on the molding and its PD testing process.

Other Case Studies

The sequence of events taken for the other cases shared here was the same as in the 600-A molded bus bar case study:

- Workers detected the presence of PD on an accessory installed in the field using the PD sniffer or PD alarm tool.
- The presence of PD was confirmed by the technical support team with the PDA system.
- The defective accessory was removed from the underground system and replaced.
- When several identical cases were detected, a PRPD analysis was done in a laboratory.
- Sometimes an X-ray scan of the accessory was done.
- A report on the origin of the PD was written.
- If the PD stemmed from a manufacturing problem, the conclusions were sent to the manufacturer to take corrective action.

Capacitive Plug of Separable Cable Joint

In 2011, Hydro-Quebec observed the presence of PD activity on more than 15 accessories newly installed in its network. For reference, the utility has more than 55,000 units of this type of accessory distributed in more than 3500 underground structures.

Table 1. Problems with and corrective actions taken on capacitive plugs of separable cable joints.

Problems	A faulty area in the molding was located at the capacitive socket. X-ray images showed some space was not filled by insulating material. Manufacturer had changed some molds, and its factory test procedure did not detect the problematic components.
Corrective actions	Hydro-Quebec informed the manufacturer of the problem associated with the molding of this type of accessory. Hydro-Quebec returned all its separable cable joints from the same lot to the manufacturer. Manufacturer corrected the molding issue and testing procedures for these components.

Submersible Epoxy-Isolated Fuse

This electrical equipment is used to provide protection for a submersible transformer in the event of an overload or internal failure. Hydro-Quebec has around 2000 fuses of this type installed in more than 500 underground structures.

Table 2. Problems with and corrective actions taken on submersible epoxy-isolated fuse.

Problems	PD was caused by air gaps inside the silicone filling, used to fill the void at the interface of three materials, including brass, fiberglass and epoxy.
Corrective actions	Hydro-Quebec replaced the fuses that had the highest levels of PD. Several tests were performed to determine if it was safe for workers to be near these components. It was concluded, due to its location, the PD activity did not deteriorate the epoxy insulation.

Cap for Grounding Device

This component is installed on padmounted switches and used to isolate the grounding device.

Table 3. Problems with and corrective actions taken on cap for grounding device.

Problems	Porosity was found in the insulation material. Incorrect bonding existed between the semiconductor and insulation material.
Corrective actions	During PD factory tests, the grounding cap was temporally installed and maintained using a hydraulic press. Test bench assembly resulted in a nonuniform pressure applied to the components and did not reflect the in-service condition. When the manufacturer was informed, it adjusted the test bench to properly detect anomalies.

T-Elbow on MV Switches

This connection accessory, often called a dead-break elbow, is used mainly to connect an underground cable to a switchgear.

Problems	Several components of this type installed on the network showed PD activity. Problematic components were removed and investigated. It was found the PD source was caused by a bad contact between the semiconductor and the lug.
Corrective actions	Manufacturing tests were made with a bigger connector than the real connector used in service. The connector used in service did not make proper contact, therefore generating PD activity. The manufacturer adjusted its test bench and was able to detect accessories out of tolerance.

Molded Vacuum Switch

This type of switch has been used on Hydro-Quebec's network since 2010.

Problems	In 2017, inspection teams identified several switches with PD issues. Switchgear were brought back to the factory to perform a root-cause analysis. Dissection showed a molded insulating disc was exposed to dust at the factory during the molding process. This contamination caused poor bonding between the rod and disc.
Corrective actions	Manufacturer made corrections to certain sensitive stages of its production to avoid dust contamination to improve bonding.

Reduced Anomalies Over Time

Hydro-Quebec's maintenance program achieves various targets. The first of these targets is the health and safety of its employees and the public. By removing potentially dangerous accessories from the network prior to their failure, Hydro-Quebec raises its safety criteria to a high level. It is a priority for the utility.

The second target is economic. The maintenance program reduces in-service failures. Performing a repair after an in-service failure is at least two and a half times more expensive than replacing an accessory after an inspection. In addition, when corrective actions are planned, there is little or no service interruption.

The third target is to ensure quality service and keep monitoring the best practices. This quality assurance has repercussions on the manufacturers. Notifying manufacturers of issues allows them to improve their processes.

Approximately 500 anomalies are detected each year by thermography and 100 anomalies by detection of PD through Hydro-Quebec's inspection program. Since the beginning of the program, the number of anomalies has greatly decreased. TDW

MICHEL TRÉPANIER (*Trepanier.michel.2@hydroquebec.com*) obtained his engineer's degree in electrical energy and electrical networks at école de Technologie Supérieure de Montréal (Canada) in 2005. He has been working since 2006 at the underground distribution division for Hydro-Quebec. He acted as technical support engineer for the inspection teams in predictive maintenance, localization and analysis of underground faults. Since 2011, he joined the underground distribution standards department. He specializes in thermal inspection, partial discharge analysis and characterization of medium voltage electrical accessories. He also contributed to several expertise and innovation projects carried out at the research institute of Hydro-Quebec (IREQ).

CLAUDE TREMBLAY (*Tremblay.claude@hydroquebec.com*) is an electrical engineer with over than 25 years of experience in engineering and project management at Hydro-Quebec Distribution. Since 2010, Tremblay is actively involved in the standards development for Hydro-Quebec and the Canadian Standards Association. He presently leads a team that provides technical support to his organisation's project planners and linemen. He is also specialized in conventional PD testing on medium voltage switchgears. Tremblay graduated from Sherbrooke University in 1993 and is a licensed member of the Ordre des ingénieurs du Quebec.

LIONEL REYNAUD (*Reynaud.lionel@hydroquebec.com*) obtained a University Technological Diploma in Electrical Engineering and Industrial Computering in 1989 and a Master's degree in Industrial Science at the Institute of Sciences and Technology of St-Quentin in France in 1990. He completed later a Master in Computer Systems at the Higher Institute of Aeronautics and Space in Toulouse in 1991. After a few years as a consultant in the private sector, he became a researcher at the research institute of Hydro-Québec (IREQ) in 1998 and participates in the development of numerous control and monitoring systems. Since 2003 Lionel Reynaud specializes in problems related to cables and accessories of Hydro-Québec's underground medium voltage distribution network. As a project manager, he leaded the deployment of tools for fault location and partial discharge detection.

MATHIEU LACHANCE (*mathieu.lachance@omicronenergy.com*) received a Bachelor of Science in electrical engineering from Université Laval in 2014. After graduating, he worked as a test engineer in the fields of partial discharges and high voltage. In 2019, he joined Omicron electronics Canada Corp. where he currently holds the position of Regional Application Specialist for partial discharges and rotating machines for North America. Lachance is a member of the IEEE Dielectrics and Electrical Insulation Society and has published technical papers for IEEE, CIGRE and other industry journals. His current focus is on partial discharge testing and electrical insulation systems.

For More Information

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Dominion Energy project team explains the horizontal directional drilling process to community members before providing a tour of the drill site.
Photo courtesy of Donnie Smith, GeoEngineers.

A Flexible Approach to Trenchless Construction

Dominion Energy uses innovative approaches to solve trenchless construction challenges on a major underground electric transmission line.

By **CHARLOTTE DEAN, JOHN KASCSAK,** and **ANN GORDON MICKEL,** Dominion Energy; and **GARY CASTLEBERRY,** GeoEngineers, Inc.

Inherent risks exist in any construction project, particularly when installing an underground transmission line. Project partners often run into unexpected encounters when working beneath the earth's surface, which forces the team to rethink its approach to meet customer demand, construction timelines and maintain company safety standards.

In 2018, the Virginia State Corporation Commission approved a 230 kV underground line, which began construction in fall 2020. The 4.3-mile line project located, in part, near a densely populated residential area was necessary due to increased electrical demand in Northern Virginia.

During the planning and engineering process, Dominion Energy selected the open trench method to install the underground cable for most of the route. The open trench method not only provided lower risks compared to other underground methods but gave construction crews the most accessibility to the work area. Additionally, the open trench method is typically installed three to four feet below grade, much shallower than trenchless methods. However, one section along the route intersects with two interstate highways and a metro rail track. The open trench method would not be feasible for this location. The team determined that horizontal directional drilling (HDD) was the best way to install the new cable under the existing facilities.

"The team chose the HDD method because it is safe and effective, the most common method of construction in these situations, and lower in cost than the alternatives," said Project Manager John Kascsak.

In spring 2021 — almost one year into the anticipated two-year project — the drilling operation resulted in several inadvertent return (IR) events where drilling fluid migrates to the surface somewhere along the drilling alignment. Certain geologic conditions, such as porous or fissured soil units and discontinuous rock formations (e.g., porous or fractured) can create an environment more susceptible to IRs than more competent formations of the same type of soil. The team documented 11 such instances between December 2020 and May 2021, seven on path one and four on path two.

The team employed enhanced techniques to mitigate against IRs in response to these occurrences. This included surface monitoring using LiDAR and hiring a specialist to monitor the condition of the drilling fluid. However, the team paused drilling

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The launch pit for the Direct Pipe solution. Project partners found that Direct Pipe was the best method to reduce the risks of inadvertent return events. Photo courtesy of Dominion Energy.

activities as mitigation measures were exhausted and ineffective during the drilling of path two. Fortunately, crews completed path one without any major IRs near the end of 2020.

Dominion Energy considered the potential for IRs in the initial planning stages. However, the location and number of IRs in short succession along path two created a potential safety concern for travelers along the interstate. These concerns compelled the team to consider alternative trenchless technologies to complete the project.

The project team partnered with GeoEngineers, an expert in trenchless technology, and chose the Direct Pipe method to finish the second path. Direct Pipe combines techniques from HDD and the micro tunneling method to install underground cables. It is a more streamlined method than HDD, as the pipe is installed as the tunnel develops. Dominion Energy chose Direct Pipe for several reasons:

- Due to the reduction of annular pressure, Direct Pipe was determined to be the best method to reduce the risks of IRs.
- Direct Pipe has a relatively small footprint, so additional work areas are not necessary.
- Most of the work can be accomplished from one side of the alignment, so there is less impact on the community.
- It reduces the time required for installation since no reaming processes are needed.

While Direct Pipe was determined to be the best solution to finish this project, it is not always the best solution for utility companies. Direct Pipe has technical limitations and is significantly more expensive than HDD. Additionally, Direct Pipe was developed after HDD, making it a newer and less tested practice in the industry.

"Both Direct Pipe and HDD are practical and effective methods to install underground infrastructure. However, both have specific technical limitations," said GeoEngineers Senior Consultant Gary Castleberry. "When evaluating a trenchless installation, careful consideration must be given to available workspace, subsurface conditions, length and diameter of the crossing and depth below the feature or obstruction to be crossed. Often an evaluation of this nature will help the design engineer and project team determine the preferred installation technique."

In addition to resolving IRs, the project team was committed to being transparent with the community regarding the project delays and thought creatively on ways to keep neighbors engaged and informed. Community outreach has been a critical emphasis since the beginning of the project, mainly due to the proximity of construction work to residential homes.

Dominion Energy hired a community liaison before drilling commenced in 2020 to provide localized support, answer questions, and relay weekly updates to community members and other local stakeholders. These updates were also made available on a new project website with interactive educational tools describing the construction methods. The team also scheduled community tours of the drill locations. This proved

Horizontal Directional Drilling vs. Direct Pipe Installation

Similarities:

- Both methods use trenchless construction to install underground pipelines, conduits, cables and other utilities along a predetermined path.
- Both use the same work areas. In this specific case, the 4.3-mile line project is located, in part, near a densely populated residential area.

Differences:

- HDD creates tunnel by drilling a small hole and enlarging the hole through incremental steps. The pipeline or utility is pulled into the hole.
- Direct Pipe installation creates a tunnel as the pipeline is simultaneously pushed through the hole. The microtunnel boring machine (e.g. cutting head) is attached to the leading end of the pipeline. As the cutting head advances through the earth, the pipeline is pushed along behind it.
- With HDD, multiple reaming passes are required to increase the diameter of the borehole.
- With Direct Pipe, no reaming passes are required, which can potentially reduce the duration of construction work.
- HDD requires drilling and support equipment on the East and West Drill Pads.
- Most Direct Pipe construction-related activities will take place on the East Drill Pad. The East Pad will become the launching pit and the West Drill Pad will become the receiving pit.
- Inadvertent releases are typically more likely to occur with HDD. IRs are events where drilling fluid migrates to the surface somewhere along the drilling alignment.
- Direct Pipe typically reduces the risk of inadvertent releases.


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most successful as it allowed the public to ask questions to the team and see the magnitude of the operations. These efforts helped the community better understand the project team's reasoning for changing the construction method.

"The completion of this project requires intense coordination with multiple local and state regulatory permitting agencies, park authorities, numerous HOA's, county agencies, county supervisors and countless internal and external stakeholders," said Kascsak. "All of this was, and continues to be, accomplished during one of the worst pandemics in modern history."

"The heightened level of outreach support for this project helped our team avoid additional permitting delays when we pivoted to the Direct Pipe method. Our goal was to finish path two as quickly as possible. Strengthening community relationships over the past two years allowed us to share our new plan quickly with local permitting agencies and resume work in an adequate timeframe," said Electric Transmission Communications Specialist Ann Gordon Mickel.

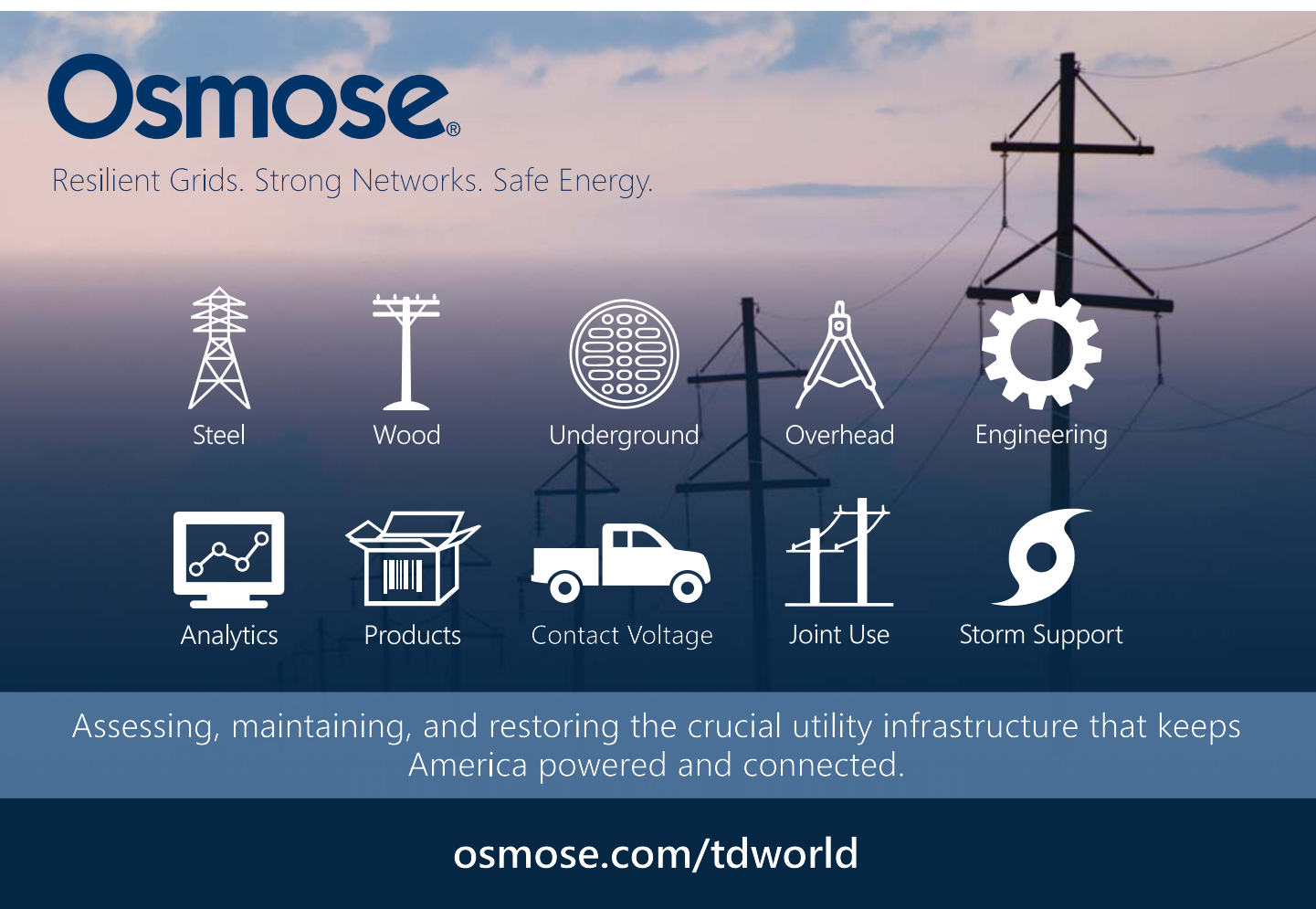
Following approval from the required permitting agencies, the Direct Pipe construction officially began in fall 2021. The team hopes to complete the process by late January 2022, with overall underground line completion by the end of 2022. TDW

ANN GORDON MICKEL (*Ann.Gordon.Mickel@dominionenergy.com*) is a communications specialist for Dominion Energy in Electric Transmission Planning and Communications. She oversees transmission projects from the conceptual phase through construction, allowing her to see the full scope of project execution and providing support to the project team. She is skilled at identifying controversial topics to help project teams navigate potential challenges, including the regulatory and local permitting process, customer demands and conflicts regarding construction. Mickel is a graduate of Elon University with a bachelor of arts degree in strategic communications.

JOHN KASCSAK (*john.j.kascsak@dominionenergy.com*) is an electric transmission strategic projects advisor with Dominion Energy. An innovative leader with more than 25 years of experience in project management, operations, maintenance and engineering & design fields, Kascsak is instrumental in the planning, design and construction of transmission and substation projects in Dominion Energy's service territory to ensure all deliverables are met to scope, schedule and budget. Kascsak is a graduate of Virginia Commonwealth University with a bachelor of science in electrical engineering and is pursuing an MBA in executive leadership from James Madison University.

GARY CASTLEBERRY (*gcastleberry@geoengineers.com*) is a senior consultant at GeoEngineers, Inc. He has been involved in the Horizontal Directional Drilling and Pipeline industries for more than 20 years. In his role at GeoEngineers he focuses on preparing feasibility studies and detailed design for HDD, Direct Pipe and other types of trenchless installations. Castleberry is a graduate of Old Dominion University with a bachelor of science in civil engineering technology and of Missouri University of Science and Technology with a master of engineering in Geotechnics.

CHARLOTTE DEAN (*charlotte.w.dean@dominionenergy.com*) is a senior communications specialist for Dominion Energy in Electric Transmission Planning and Communications.She serves as chief copy editor managing internal and external stakeholder communications. She also supports the development of communications on behalf of the organization that are responsive to distinct audiences. Passionate about volunteering, she serves as board chair of the Chester Family YMCA and is a board member of The Next Move Program. Dean is a graduate of Virginia Commonwealth University.



ELECTRIC UTILITY OPERATIONS

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MidAmerican Energy:

Infusing Technology into Apprenticeship Training

CONGRATULATIONS
TO OUR FEBRUARY FEATURED LINEMAN!

Rick Soto
E-J Electric

- Born in Manhattan, New York, and has a younger sister.
- Married to his wonderful wife, Kaitlynn. They are expecting a baby girl in April.
- Inspired by his parents, who have been married for 36 years. He says he is grateful for all their love and support.
- Is the first lineman in his family.
- Enjoys working around the house and starting new projects such as painting, carpentry and lawn care. He also likes four wheeling and visiting the gun range.
- Can't live without a sharp knife for quickly skinning all types of wire, and battery-operated power tools like drills, cutters and crimpers.

Journeyman Lineman Rick Soto says during storm restorations, it feels great to help others in need.

Early Years

Seven years ago, my good friend Karl told me about line work. I was in desperate need for a career change, and I feel forever indebted to Karl for taking the time to help and guide me into this trade. It has completely changed my life for the better. My first job in this trade was working distribution for Thirau Utilities in Queens, New York. As a brand new apprentice, I didn't have the slightest clue about what I needed to do. Thankfully, all the linemen in Local 3 immediately took me in as one of their own and began teaching and showing me how to prepare the materials needed for any job, how to operate a bucket truck, skin wire and much more.

Challenges and Rewards

I truly love what I do, and the friendships I have made are priceless. At the same time, linemen face many hazards like possibly falling from extreme heights, electrocution or worse. Each move is crucial. One mistake can result in accidentally hurting yourself or your partner.

Another challenge is the weather. We work in hot summer days and the cold of winter. It is also difficult trying to juggle being a good lineman and a good family man. Due to my lengthy commute, long hours and occasional travel for storm work, I spend more time in my bucket truck than I do at home.

Safety Lesson

The importance of safety is always a number-one priority for us. It is drilled into us the moment we enter the apprenticeship program, but unfortunately, every now and then, you hear about a serious injury or fatality that seriously hits home. Whether you have personally known them and worked alongside them or not, hearing about any injury or fatality is never easy to process. I reflect on how dangerous our job could be and just how delicate all our lives really are and how important safety needs to be.

Memorable Storm

I'll never forget the first storm I ever went on. I was new in the trade and unfamiliar with the process of storm work. When I got a call that we were being mobilized for a storm, I packed a bag and hurried back to the yard, not knowing how long I would be away from home, exactly where I would be staying or what I would encounter when I got there. It all added to the thrill of that first storm moment for me.

It lasted two weeks, and luckily, we had good working conditions. The utility was grateful to us for answering its call for help.

Life in the Trade

I would absolutely go into the power industry if I had to do it over again. It has challenged me and changed my life in so many ways. It has provided me with a great quality of life and meaningful friendships I will have the rest of my life. I feel like line work has so many divisions and aspects to it that there is always something to learn.

Future Plans

I plan to continue to educate myself about the different aspects of my trade to help me grow to be a better lineman and hone my skills.

Another one of my goals is to learn leadership skills from my mentor, Bladimir, who is by far the best lineman I have ever had the pleasure of working with. TDW

Editor's Note: 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. To thank him for his dedication to the line trade, Milwaukee Tool sent a tool package to Soto.

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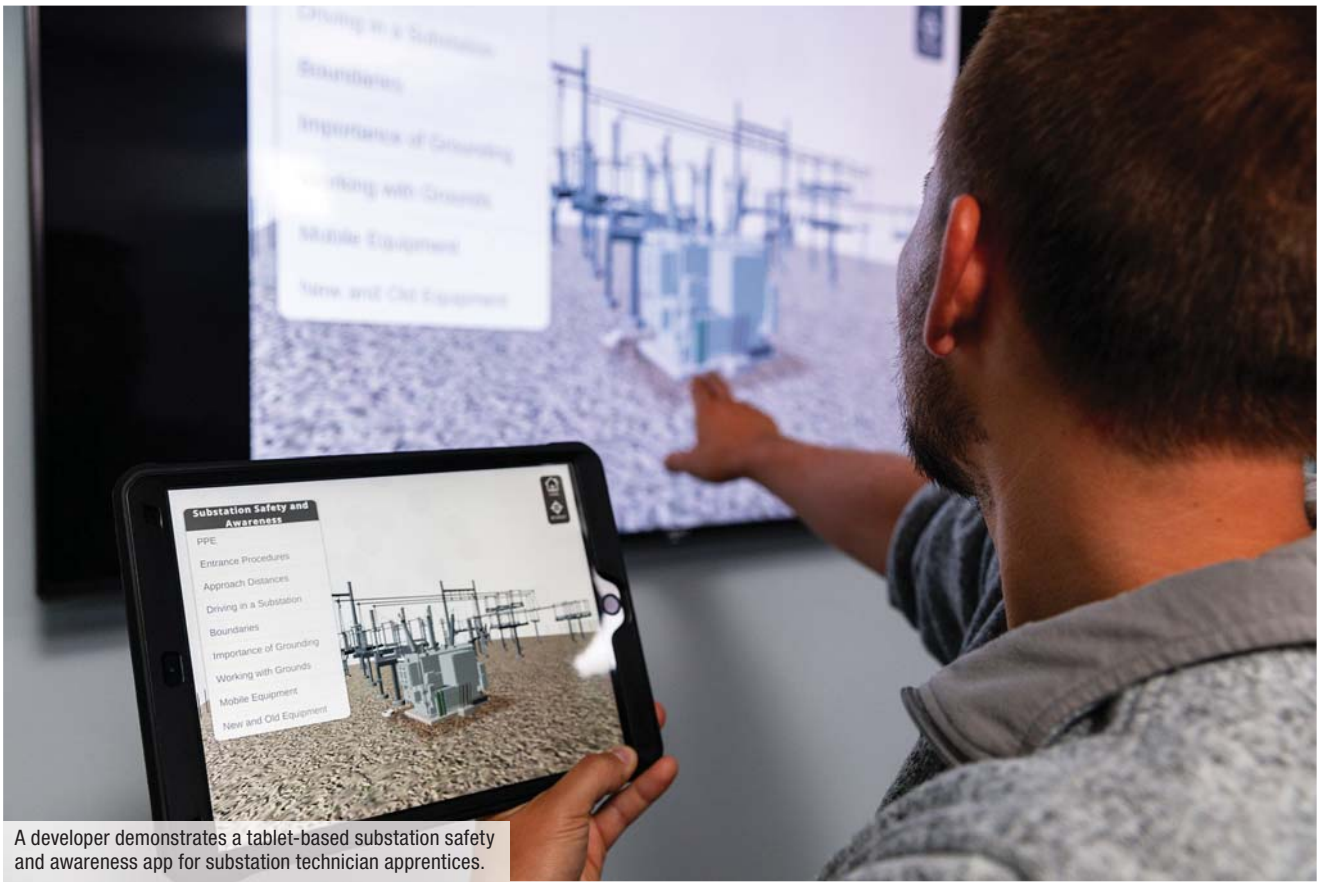

A developer demonstrates a tablet-based substation safety and awareness app for substation technician apprentices.

Infusing Technology into Apprenticeship Training

MidAmerican Energy rolled out a digital curriculum to supplement the training program for its substation workforce.

By **AMY FISCHBACH**, Field Editor

Not so long ago, apprentices could only learn skills and best practices through hands-on training. Today, apprentices can explore equipment within a substation anytime and anywhere through MidAmerican Energy's digital training curriculum.

Through a combination of animations, augmented reality (AR) and 3D modeling, apprentices can view components from any angle, visualize complex tasks and better understand how equipment works.

The curriculum also incorporates video demonstrations from other technicians and electricians across the company to supplement the apprenticeship content. While much of the apprenticeship is hands-on learning, the new digital curriculum can help bridge the gap when apprentices do not have the opportunity to work on those devices in the classroom or field.

Transitioning to Digital

Prior to implementing the digital curriculum and construction of MidAmerican's Training Center for Excellence in Des Moines, Iowa, continuing education for the journeymen was extremely limited, says Chelsea McCracken, vice president of safety, training and development at MidAmerican Energy. Supplemental training was limited to what could physically be lined up and worked on at any given place or time. Even then, the apprentice would have to travel to that location to experience what was being presented. MidAmerican Energy developed mock units for each work location and reviewed and shared text-heavy lessons-learned documents among groups.

Delivered via tablets assigned to each new worker, however, the new digital curriculum, developed in partnership with

Index AR Solutions, will continue to be available for reference even after they top out as journeymen and help the next apprentices. With the new digital curriculum, MidAmerican's own personnel can fully capture these events and training opportunities on video and incorporate them into the appropriate section of the eBooks. This approach enables anyone to consume training content in a consistent manner, anywhere at any time.

Training Users

When rolling out the digital curriculum, it was essential to secure buy-in and engagement from everyone in the training process, McCracken says. This includes assigning a dedicated project leader, identifying subject matter experts early in the curriculum development process and helping represented workers understand their stake in the outcome. It is important for apprenticeship trainers and workers to understand how the material will be created and used, as their involvement is key to project success, she added.

After training is complete, workers can continue using their training tablets whenever they need to see an example of a device configuration or when they need refresher on a complicated procedure. Standards and safety rules are available and searchable on the devices, making them a convenient reference tool.

Imagery is used to reinforce Human Performance Improvement (HPI) concepts in substation technician apprenticeship digital training.

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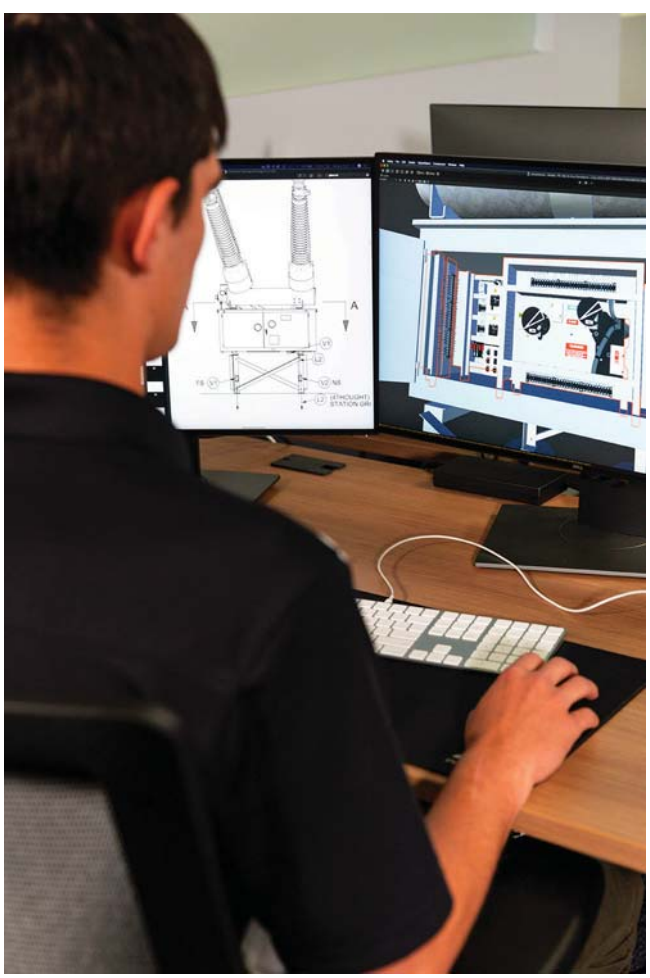
A worker discusses enclosed capacitor bank safety and maintenance for a video to be embedded in a training eBook.



A developer works on a mobile app that helps substation technician apprentices visualize substation components.

Investing in Mobile Technology

At MidAmerican Energy, substation technicians and electricians have a company-issued mobile phone and a company-issued laptop to perform their work-related tasks. As digital training content was being developed and after it was issued as final, company-issued tablets were used as the primary delivery mechanism. All final eBooks and mobile app visualizations are available on these managed company devices at each department location across the state.

On their first day, new substation technician and electrician apprentices receive a company-supplied tablet preloaded with the digital training material and supporting items such as standard manuals and safety rule books. Apprentices keep their tablets and use them as a field reference after training is completed. Electronic bookmarks and notes stay with each apprentice.

In addition, apprentices can access training eBooks on the company-issued mobile phones. MidAmerican also assigns technicians rugged devices for field work.

Training on the Go

MidAmerican Energy, which has 35 substation technicians, shifted from a four-year Substation Technician and Electrician apprenticeship to a three-year program.

"Condensing the apprenticeship into three years makes it essential that the training materials are high quality and accessible to technicians/electricians no matter where they are," McCracken says.

The digital curriculum helps to train substation technician and electrician apprentices on the work they do in the field, as well as the laptops and other tools they rely on each day. This includes relay testing and troubleshooting, proper use of physical tools like multimeters and relay test sets, as well as "soft" tools like Human Performance Improvement (HPI) tools, safety rules and common practices such as setting up work boundaries.

The eBooks and apps comprising the digital curriculum provide apprentices a way to learn on their own using a familiar platform and a format that works best for them. The curriculum delivers information in a multi-modal fashion, using rich text, video and augmented visualizations that supplement the apprenticeship.

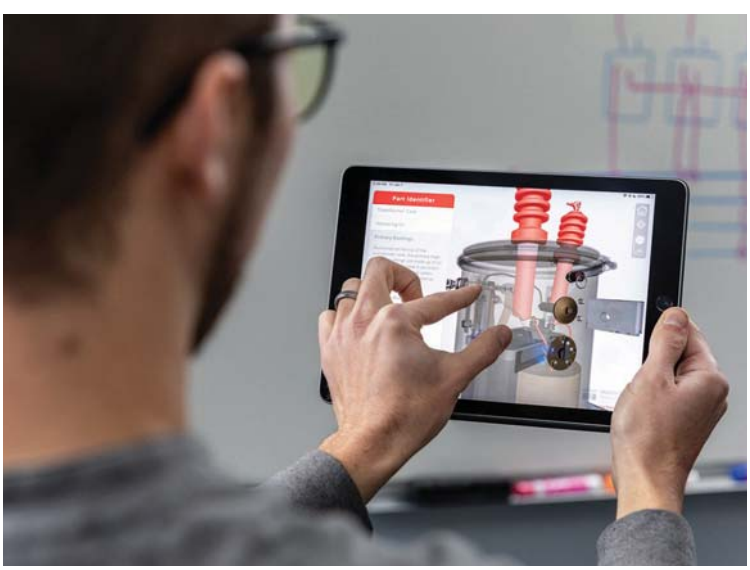
Advancing in the Apprenticeship

Once the substation technician and electrician apprenticeship is underway, every six-month phase includes a 40-hour week at MidAmerican's Training Center for Excellence. Peer evaluations are given each month and reviewed by the Local Apprenticeship Committee via conference call. As an apprentice

Videos ensure expert knowledge is captured and consistently shared.

progresses through the training phases, they will use the tablet-based training elements to supplement and reinforce concepts learned in the Training Center for Excellence and better understand related material.

A Line Mechanic digital curriculum is currently in development. Once complete, line mechanic apprentices will use the curriculum in conjunction with NJATC materials for an immersive learning experience. Visualizations and training videos featuring subject matter experts complement written eBook instructions to show apprentices how to virtually wire transformers, understand how various types of equipment operate and more.



Augmented visualizations help reinforce important concepts and boost knowledge retention.

Taking a Hybrid Approach

The benefits of using a digital curriculum, which can help teams seamlessly transition from in-person training to virtual training, came into focus during the pandemic. MidAmerican apprenticeships that had deployed a digital curriculum were able to continue during work modifications necessary to respond to COVID-19 guidance from state and federal agencies with minimal impact to training schedules.

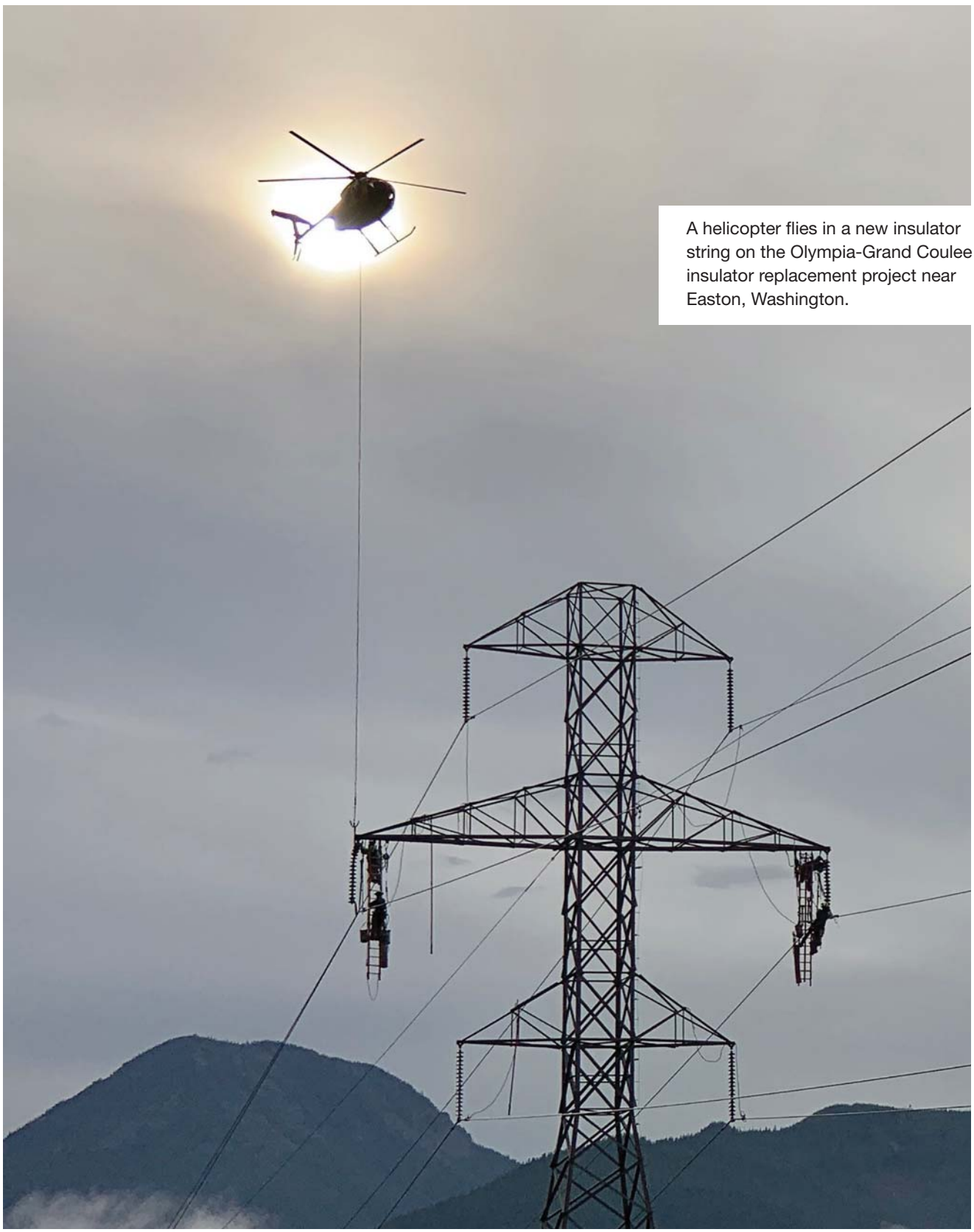
The recent global pandemic disrupted many business operations, particularly those requiring in-person gatherings. A mobile training platform can help minimize the impact of facility closures, prevent apprentices from falling behind and help ensure that staffing levels remain sufficient.

Hands-on and classroom training will continue to be a critically important component of MidAmerican apprenticeships, including those related to electric operations. The digital curriculum is a valuable supplement that helps reinforce concepts and procedures learned in the classroom using a device that can be taken anywhere. TDW

AMY FISCHBACH (*amyfischbach@gmail.com*) is the Field Editor for *T&D World* magazine.

Parting Shot

Photo by **BILL KREKE**



A helicopter flies in a new insulator string on the Olympia-Grand Coulee insulator replacement project near Easton, Washington.

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Reimagined Microgrids

With high-impact, low-frequency events on the rise, utilities need to develop a proactive resiliency program including strategic hardening, microgrids and undergrounding.

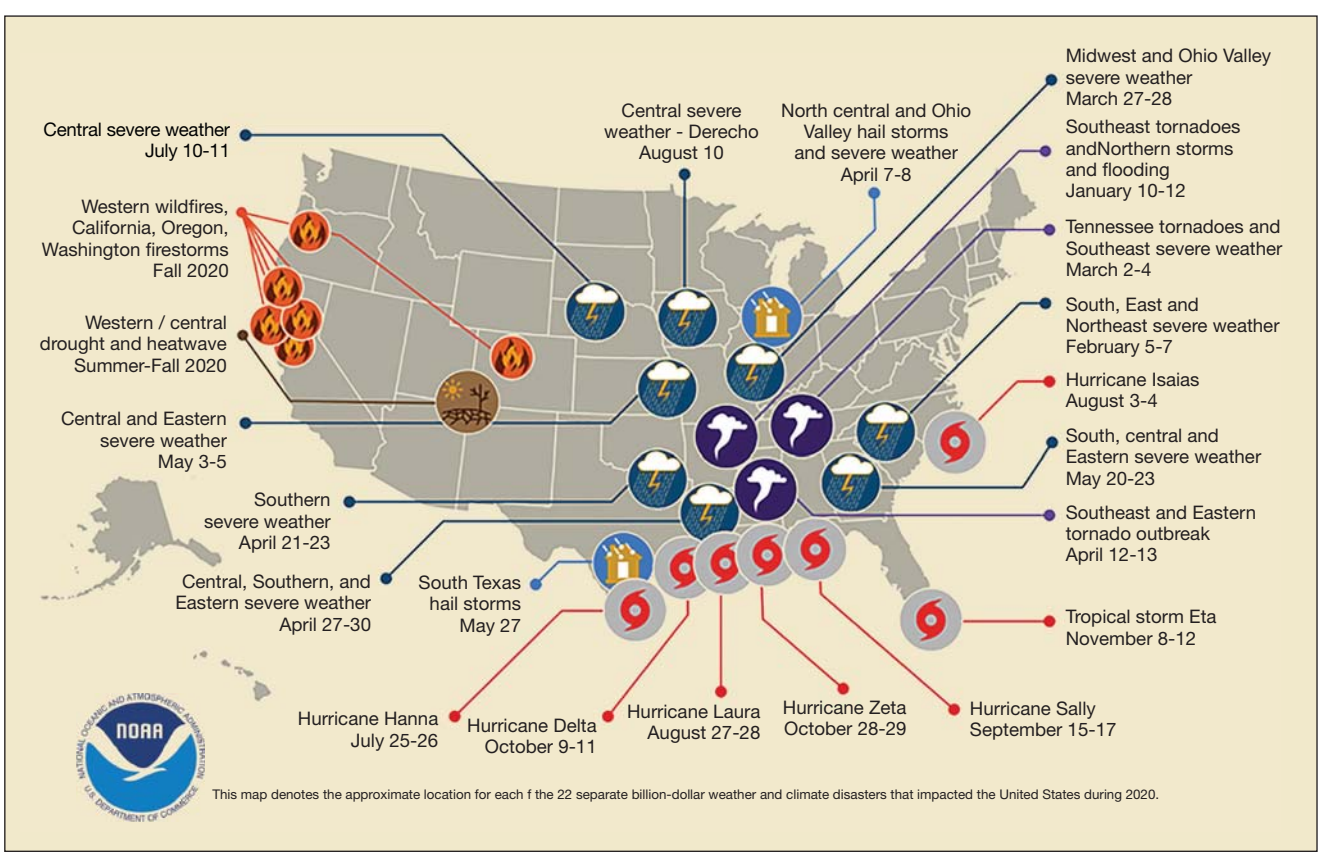
By **MICHAEL E. BEEHLER**, Mike Beehler & Associates LLC, and **ROBERT E. KONDZIOLKA**, California ISO Western Energy Imbalance Market

Customers without electricity for days or weeks? Does that happen in the U.S. in the 21st century? Increasingly, the answer is yes. Wildfires, hurricanes, ice storms, floods and other events seem to come more frequently and with greater intensity. It is well past time to accept these devasting and life-threatening outcomes and pursue new approaches to resiliency to protect communities from high-impact, low-frequency (HILF) — or black sky hazard — events.

Electricity is fundamental to the health, safety and economic vitality of the U.S. It is the fundamental critical infrastructure that must operate for other critical infrastructure to function. Communications, water purification and distribution, wastewater systems, fuels, transportation, medical services, financial systems and physical security do not function when impacted by HILF events without a resilient electric system.

According to the National Oceanic and Atmospheric Administration (NOAA), the U.S. experienced 22 separate billion-dollar weather and climate disaster events in 2020. Significant and major power outages were associated with these events. The trend did not improve in 2021. The extreme cold weather event in February 2021 from winter storm Uri wreaked havoc on the Midwest. Texas suffered outages and rolling blackouts for days, and the Federal Energy Regulatory Commission (FERC) and North American Electric Reliability Corporation (NERC) launched an investigation into the impacts and causes. Then, in August, massive power outages occurred when Hurricane Ida hit landfall in Louisiana. New Orleans went black for days when all eight transmission lines into the city were damaged from the hurricane winds and debris. The extent of damage from a tornado outbreak across five states and derecho winds from Colorado to Michigan in December is still being determined.

Other notable events in recent years include the 2017 Hurricane Harvey flooding in Houston, Texas, the 2017 Hurricane Maria

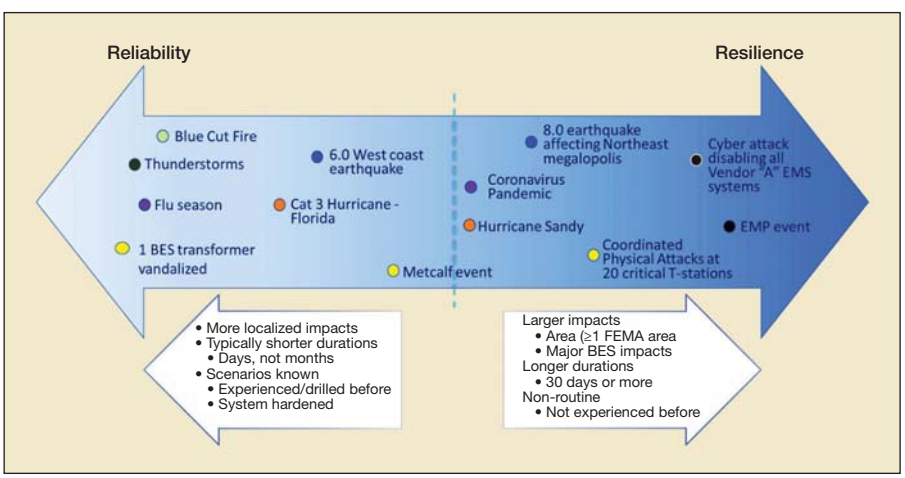


Map of U.S. billion-dollar weather and climate disasters in 2020. Graphic by NOAA National Centers for Environmental Information

devastation in Puerto Rico and the U.S. Virgin Islands, the 2018 Bomb Cyclone that caused severe disruption along the East Coast and Canada, the 2018 Camp Fire that was the deadliest and most destructive wildfire in California history, the 2019 Polar Vortex that created a severe cold wave in the Midwestern U.S. and Canada, and the increase in wildfires in the West.

The value of critical electric service and critical infrastructure that electricity supports immediately after these high-impact storms and events is immense. Without some level of survival of the electric system, lives are lost; local commerce, education and medical care grinds to a halt; and personal safety, security and well-being are at perilous risk. The frequency and magnitude of these HILF events are increasing; therefore, improving the resiliency of the electric grid is imperative and will be key to managing an uncertain future of more HILF events.

June 2005 wildfire in Phoenix, Arizona, causing outage on six circuits of 500-kV, 345-kV and 230-kV transmission lines. Photo courtesy of the authors



Reliability-resilience continuum diagram. Graphic by NATF Transmission Resilience Maturity Model

What Is Resiliency?

Many organizations, including the Electric Power Research Institute (EPRI), NERC and the North American Transmission Forum (NATF), have developed succinct definitions of resiliency in the context of electric infrastructure. In short, resiliency is the ability to reduce the magnitude and duration of extreme disruptive events through prevention and preparedness, response and recovery.

Improving resiliency does not mean building everything bigger and stronger: that may not be the most economical choice or the best use of resources. Improved resiliency should prevent a complete loss or collapse of the electric system by prioritizing the survival of key elements of the electric system that support critical infrastructure, with the remaining electric system able to be more readily and rapidly restored by building off the surviving core. A resilient electric system will provide continuity of service to all areas of critical infrastructure as well as targeted and select areas in the community. There may be some failures or losses, but the failures from HILF events should not lead to a total loss of the system. As a result, a more resilient system can be restored faster, with better triage and restoration time estimates for stakeholders.

A gray line exists between major adverse reliability events and extreme catastrophic resiliency events. NATF collaborated with EPRI, the U.S. Department of Energy (DOE), and the Pacific Northwest National Laboratory (PNNL) to develop a transmission resilience maturity model (TRMM). The model provides a relative perspective of extreme and catastrophic events on the reliability-resiliency continuum spectrum and the key differentiators that define resiliency events. Improvements made to increase reliability performance during HILF events do not necessarily increase resiliency performance. However, improvements made to increase resiliency during HILF events will improve the reliability performance during major adverse reliability events.

As noted previously, an unfortunate trend is these major events are adversely impacting the electric system with increased frequency, affecting larger areas and more people for longer periods of time. Beyond preparing for natural occurrences (for example, extreme storms of all types, earthquakes, volcanoes and tsunamis), utilities need to be prepared for a wide range of HILF resiliency events, including cyberattacks, physical security attacks, sabotage, terrorism, communication failures, geomagnetic and electromagnetic disturbances, and systemic software and technology failures. Developing comprehensive resiliency plans for HILF events is underappreciated but vital. Utilities must do more to strategically plan and enhance the electric grid to survive HILF events and incorporate resiliency as a cornerstone of electric service.

Upgraded and hardened substation key part of new, reimagined microgrid. Photo courtesy of the authors.

Reimagine Microgrids

How can utilities build a better and more resilient electric grid that serves the community when it is needed most? A new definition of microgrid is a good start. A new microgrid approach to improved resiliency needs to be holistic with strong integration among traditional and renewable generation resources, transmission, distribution and end users. Utilities need to build microgrids strategically that reduce risks and exposures by initiating long-term investments to achieve high levels of resiliency maturity against HILF events for all stakeholders.

Microgrids must be planned, designed and built to provide real resiliency to communities of all sizes. In the past, many have envisioned microgrids as self-sustaining electric islands that can be separated from the grid in times of distress and operate autonomously for extended periods of time, relying on distributed generation sources. However, conceptual microgrids do not achieve economic and environmental objectives; therefore, utilities have not incorporated this approach into their resiliency plans.

Microgrids need to be redefined. They should be reimagined with the development of electric infrastructure that will provide critical electric service to strategic areas throughout a community during times of greatest distress. This includes targeted hardening and strategic undergrounding of the most critical T&D lines and upgrading substations to ensure electric service can be provided to other critical infrastructure and areas designated as critical for continuity of communities.

Imagine a select portion of the grid remaining in service after a wide-area catastrophic event. The surviving partial system would provide service to multiple small portions of communities across a large metro area. Even if homes were out of power, potable water would still be available. Toilets could be flushed and sanitary systems could still function. Mobile phones could still operate and customers could still access news and emergency information. Phone charging stations could be available and a limited number of grocery stores and gas stations could still operate. Community centers could be available for heating and cooling in extreme weather as well as providing food, water and shelter. Reimagined microgrids would survive catastrophic events, remain operational, and provide electric service to multiple small areas (microgrids) of communities across large service territories.

Part of this new approach to incorporate resiliency into the grid is to rethink how the most critical corridors, circuits, stations and equipment are planned, designed, constructed and protected. They should be planned, designed, constructed and protected much the same as black-start generation and cranking paths.

Utilities could prioritize these resiliency paths, circuits, stations or equipment for the different parts of their grid. For resiliency purposes, the portions that should never go down during a HILF event could be designated as "secure and functional." The next highest level would be those lines and stations that should be restored first. They would be designed and constructed such that they would sustain much less damage and, therefore, could be restored more rapidly than other lines. They could be designated as "prepared for rapid restoration." Lastly, the other parts of the system could be designated as "standard construction."

High-quality standards keep utilities focused on average reliability performance and not resiliency. In the past, utilities worked hard to make the electric grid as uniform as possible. This provided consistent training, material inventory, tools, economics and uniformity across the service territory. Standards assume an average life span for normalized events over the depreciation time frame. They do not consider or incorporate HILF events. The typical use of standards blinds utilities from resiliency measures like functional microgrids. In the future, utilities need to optimize the principles of prevent, respond and recover into the planning, design, construction, and operation of a more resilient grid.

Common corridors are big resiliency risks. Utilities evaluate multiple circuits on common structures and multiple circuits in a single right-of-way width from a reliability perspective. Detailed analytical studies are based on deterministic and statistical computations for likelihood of occurrence, loss of load probability and other such approaches. Reliability standards are in place for common corridors; however, they are not evaluated on a HILF event and resilience basis.

Undergrounding just one transmission line in a common corridor could mitigate the losses from several types of HILF events, such as wind and debris from extreme storms, wildfires, flooding, environmental contamination, physical attacks and terrorism.

Build For Resiliency

Building for resiliency is comparable to physical financial risk hedging against a HILF event. As there are no financial instruments that can purchase operational physical infrastructure, especially in the aftermath of a catastrophic HILF event, utilities should invest in physical resiliency as an alternative to spending money purchasing risk damage insurance.

Industry groups such as EPRI, NATF and NERC among others have been advocating for increased resiliency against catastrophic HILF events for more than a decade. However, utilities have many current and near-term pressing requirements:

1. Decarbonizing the grid (clean energy conversion at utility scale, distributed energy resource integration, electric vehicle integration, system improvements to manage variable energy resources, interconnection queue).
2. New load/customers.
3. Reliability and operational flexibility improvements.
4. Customer improvements.
5. Normal operations and maintenance (O&M) and storm-response programs.
6. NERC reliability standards.

The industry needs to undertake a progressive, strategic investment program to harden critical elements of the grid, including strategically undergrounding select T&D lines to ensure continuity of service and quick restoration. Resiliency will include a stronger grid, upgraded substations and newly defined microgrids.

Utility executives and local and state regulators are the initial focal point for ensuring there is a focus on resiliency and plans to achieve it. The boards of utilities should ensure resiliency is addressed in strategic plans and funding initiatives. The business community and community leaders should have conversations with utilities and regulators on the need and value of being prepared for HILF events. Utilities and regulators also need to shift some of the reliability expenditures into resiliency investments. Resiliency improvements usually have the effect of providing benefits to reliability.

Planning, designing and building resiliency improvements like new microgrids along with all the other O&M and capital improvements is a tremendous coordination challenge. Only so much work can be done in any given year. These types of resiliency improvements take time and utilities need to develop 5-, 10- and 20-year plans to achieve resiliency goals.

When considering the costs and benefits of improved resiliency, utilities and regulators must work collaboratively to define the needs for the communities they serve and regulate. Long-term plans need to be developed to achieve high levels of resiliency maturity for HILF events. They must identify permanent funding mechanisms to provide certainty to the plans and improvements. One such option can be the development of a small percentage of overall spending specifically dedicated to microgrid resiliency plans. The value of the resiliency improvements should quantify items not normally captured by traditional cost-benefit analysis:

- Direct cost of losses to homeowners and businesses.
- Negative impact on life and property.
- Immediate and near-term economic impact to the community.

This important corridor could be designated "secure and functional" and have at least one underground circuit to the microgrid. Photo courtesy of the authors

- Long-term impact to the economy
- Negative impact to the social fabric of the community.

The economic and social impacts to communities need to be incorporated into the overall assessment. The total cost of ownership (TCO) over the life of the asset has been neglected by most of the electric utility industry for decades.

Catastrophic HILF events could happen at any time. Utilities always need to be prepared for any type of catastrophic event. A failure to act now means the scenarios that happened in Texas and New Orleans will be repeated many times in the future. There is a lot of complexity and detail to develop a well-conceived resiliency plan that includes reimagined microgrids.

Resiliency improvements to the electric system must be made as cities and communities develop and implement a strategic program of resiliency, so that no metro, urban or rural area is in this situation again.

Start Preparing Now

The value of electric service and the critical infrastructure that electricity supports immediately after these high-impact events is immense. Lives are lost; local commerce, education, and medical care grinds to a halt; and personal safety, security and well-being are at heightened risk when the electricity is off. Electricity is critical to protect the vitality of communities, and that pressure increases with the size and density of a metro area. The challenges for improved resiliency become even greater as electrification of buildings and the transportation sector are considered.

Knowing and having certainty a community is safe, with access to the basics of life, and that help is on the way enables everyone to come together, with neighbors helping neighbors. A well-planned, -designed and -built resilient electric system will provide continuity of service to all areas of critical infrastructure as well as targeted and select areas in the community.

Improved resiliency does not necessarily require everything to be built bigger and stronger. A resilient electric system with microgrids that serve critical loads will not allow a total loss of the system and everything it serves. Improved resiliency maintains service to critical infrastructure and enables better triage, improved restoration estimates and more rapid responses on the balance of the system.

This new paradigm of planning, design and prudent investment in reimagined microgrids with strategic hardening and undergrounding of lines will prepare utilities for the high-impact storms, wildfires, attacks and other HILF events of the future, while dramatically reducing the negative impacts on life, property, business, the economy and the community social fabric. Now is the time to start. TDW

MIKE BEEHLER P.E., (*mebeehler@aol.com*), is the chief opportunity officer for Mike Beehler & Associates LLC and is the nationa spokesperson for the Power Delivery Intelligence Initiative. He started his career designing and building transmission lines and substations for Tucson Electric Power and the Hawaiian Electric Co. and then spent more than 20 years designing T&D infrastructure and consulting on emerging trends at Burns & McDonnell. He has written, presented and consulted on reliability-centered maintenance, critical infrastructure protection and program management. In addition, he is a well-known industry writer and speaker on the early definition of the smart grid, 3-D and building information modeling applications in T&D, and development plans for smart cities. Most recently, he is sought for his strategic leadership and vision on the application of emerging technologies in changing business models to include the integration of distributed energy resources, augmented/virtual reality and artificial intelligence. He authored the book, The Science of the Sale. Beehler is a registered professional engineer in Arizona, Florida, Hawaii, Texas, Colorado, Kansas, Georgia and Alabama. He also is a Fellow in the American Society of Civil Engineers and a member of IEEE and CIGRE.

ROBERT E. KONDZIOLKA,P.E., (*rekondzi@gmail.com*), has over 40 years of experience in engineering, planning, budgeting, line routing, public involvement, project management, design, construction, real-time operations, maintenance, reliability standards and overall management of electrical transmission systems. Kondziolka is a governing body member of the California ISO Western Energy Imbalance Market (EIM) and currently serves as vice chair. Prior to becoming an independent governing body member on the EIM, he worked at Salt River Project for 36 years. When he retired from Salt River Project, Kondziolka held the position of management consultant for grid resiliency and security. Previous management positions at Salt River Project included director of transmission line design, construction and maintenance, director of power delivery engineering, director of transmission and generation operations, executive manager of transmission planning and development, manager of transmission line design, project engineer for the Mead Phoenix project, and supervisor for transmission line structural and geotechnical engineering. Kondziolka was a senior engineer at Salt River Project and design engineer at Tucson Electric Power, addressing all aspects of transmission line design and development. A registered professional engineer, Kondziolka has been involved in industry organizations, received several awards for research and industry contributions, and authored and coauthored technical articles related to transmission line systems. He has been involved in many of the efforts to achieve a more coordinated and unified Western Interconnection to improve reliability and economics.

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Recent wildfires in the Australian bush have resulted in billions of dollars in damage. Photo by United Energy

Three Strategies for Mitigating Wildfire Risk

A collaborative effort is required to mitigate the growing danger of more frequent wildfires from climate change.

Australians, especially those of us who hail from Victoria, are no strangers to wildfires. Nestled on the southern tip of the continent, just north of Tasmania, the state is one of the most fire-prone regions in the world. In 2019 and 2020 alone, 1.5 million hectares (about 3.7 million acres) of bush burned in the state — resulting in 420 homes destroyed, several deaths and an unmeasurable impact on our unique ecosystem, wildlife and biodiversity. We've also suffered through three of the largest, most destructive wildfire events in our country's history — in 1977, in 1983 and in 2009.

Unfortunately, much of the devastation is a direct result of human activity — including sparks originating from assets that make up our electrical grid. According to a government investigation into the Ash Wednesday wildfires in 1983, 29 of the 190 fires were started by malfunctioning assets on the electricity grid — or roughly 15%. I remember sitting on my mother's front porch in 1983, watching embers fly over our property from flames more than 50 km away. An investigation after the Black Saturday wildfire in 2009 found that five out of the 11 major fires were sparked by power lines.

Considering the destructive nature of wildfires in the region and the potential for a loss of life, the electric utilities here in Victoria and other fire-prone regions around the world have an obligation to our community, our environment and our shareholders to make our grid as resilient as possible. The benefits of a resilient network go well beyond preventing fires. Access to electricity helps provide the lifeline that communities need to stay informed and connected with family, friends and neighbors, which is particularly important during wildfire season. Similarly, an uninterrupted electricity supply can be invaluable for maintaining pumps and other essential home systems in case of emergency, especially in remote areas.

It is going to require a commitment from the industry, customers and governments to purchase, deploy and maintain new fire prevention technology to prevent fires from breaking out before they start. A collaborative effort is required to mitigate the growing danger of more frequent wildfires from climate change.

And, Of Course, It's Getting Worse

As temperatures continue to climb and extreme weather increases the frequency and magnitude of droughts and dry conditions, the devastation wrought by catastrophic wildfires are the number-one

risk to the industry. According to the National Council for Fire and Emergency Services, the Australian wildfire season has increased an entire week per year over the past decade. That means that there are an additional 70 days per year of extreme wildfire risk today than in 2011. That's 70 more days of heightened vigilance for our networks and the community.

United Energy, the third largest utility in the state (and my employer), has 10% of our total assets in areas determined to be at a high risk of wildfires. This includes cabinets, transformers and overhead wires that traverse forest grass and leaf litter. A simple spark is all that is needed to ignite the dry vegetation and start a fire.

A large portion of United Energy's network is overhead and exposed to a variety of potential sources of damage. Through the use of digital monitoring systems, however, United can detect and receive alerts about irregularities on the network caused by such incidents. Photo by United Energy.

Three Strategies for Reducing Wildfire Risk

The industry needs to develop fire reduction strategies that prevent fires from starting in the first place. This includes improving design standards for existing equipment, developing new technology solely dedicated to spark prevention and leveraging better asset management strategies that prevent overvoltages from occurring in the first place.

Improve Design Standards

Most legacy equipment on the grid is rated for 35 degrees Celsius (95° F) — an understandable cap from a time when temperatures rarely exceeded that limit. But the world is a hotter place than it was 50 years ago when these assets were first manufactured. It now regularly gets over 40 degrees Celsius (105° F) throughout the summer months in Victoria, and it's not uncommon for it

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SPU devices deployed on a utility pole in the field (left); Hitachi Energy's Spark Prevention Unit (SPU), (right). Photos by Hitachi Energy.

to top 45 degrees Celsius (113° F). Other fire-prone areas in the American West and Spain are experiencing rising temperatures as well.

While many equipment manufacturers already stress test their products to perform under today's extreme weather conditions, regulations that force all equipment manufacturers to meet higher temperature standards would go a long way toward reducing asset malfunctions that result in sparking. This would improve safety features across the board and greatly reduce wildfire frequency.

Develop Spark Prevention Technology

A potential area of risk that is being addressed, in cooperation with suppliers like Hitachi Energy, is surge arresters installed on overhead distribution wires, which can be a source of sparks that potentially leads to wildfires. They work by protecting critical assets from overvoltages due to lightning, overheating or even routine switching events. If the overvoltage is particularly severe in terms of size or duration, the surge arrester is designed to sacrifice itself to protect downstream electrical equipment. Depending on the voltage surge, these events can be quite dramatic, releasing hot gasses that spontaneously spark.

Utilities now have the option to deploy spark prevention units (SPUs) to reduce wildfire risk caused by thermally overloaded surge arresters. Installed directly on surge arresters in areas at high risk of wildfires, SPUs monitor the current and thermal load of the surge arrester and automatically disconnect it from the network in the event of thermal overload. This prevents any arcing, sparking or ejection of hot particles that may ignite nearby vegetation. Developed specifically to reduce the risk of fire in Australia and California, tens of thousands of SPUs are now deployed in high-risk areas around the world. The SPU can be deployed on networks in every kind of terrain, regardless of location, and it's been a great way to eliminate one potential fire hazard and deliver out-of-sight, around-the-clock protection without the need for boots on the ground.

Commitment to Better Asset Management

A very large portion of our network (around 80%) is strung overhead and is exposed to a wide variety of potential sources of damage that can be highly unpredictable. Unfortunately, animals such as birds, bats and possums get caught in our overhead lines and, on occasion, can present a fire hazard. Using digital monitoring systems, however, we can detect and receive alerts about irregularities on the network caused by such incidents. Asset management strategies can provide new insights into grid health and behavior through real-time awareness in the control room.

Operators can use remote monitoring solutions to gain near real-time control and analysis of grid production and health as well as a range of insights used for predictive optimization and planning. Manufacturers such as Hitachi Energy are proposing digital solutions to monitor the state of surge arresters anywhere on the grid to increase reliability and safety. The wireless monitor for surge arrester, for instance, records surge events as well as leakage current, environmental conditions such as ambient temperature and humidity and transmits this information via long range-low power network communication. Powered by batteries, this kind of monitor can be placed anywhere on the electrical grid and transmit information on a regular basis, contributing to the increased resilience of the grid.

Powered by artificial intelligence (AI) and machine learning (ML), there's a whole range of digital solutions that allows operators to watch energy flow, turn generating sources on and off, monitor energy quality, warn technicians about live wires and conduct other actions remotely and automatically. Imagine being warned of an impending overvoltage event and being able to simply turn off that asset and redirect load over other infrastructure without disrupting supply. Or, better yet, automate those predictive and proactive actions without needing human interaction.

The Time to Act is Now

Climate change is a problem that's not going away. Rising temperatures and more devastating events are going to continue to threaten the electrical grid and potentially cause more wildfires. With lives, property and wildlife being put at great risk, it is essential that the industry take the necessary steps to commit to using new technology to stop fires from starting in the first place. Improving design standards, deploying new technology, such as the SPU and the REFCL (rapid earth fault current limiters) and leveraging the capabilities of a new wave of digital technologies are some of the ways we have made significant progress in Victoria. As a result, we've been able to achieve a 30 to 35%improvement in the control and mitigation of wildfires in our state since 2011. Every fire we stop will have a major impact on the communities and customers we serve — and that is something worth working toward. TDW

CRAIG SAVAGE is head of Network Performance and Management Systems for United Energy, Victoria, Australia.

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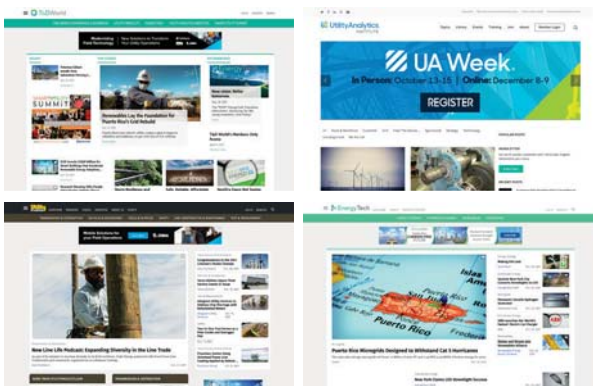

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A trusted industry resource for more than 65 years, T&D World's mission is to provide utility executives, managers, engineers, supervisors, operators and linemen with must-read information on the design, engineering, construction, operation and maintenance of the electric power-delivery system.

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

Smart Glasses

The Pepperl+Fuchs brand ECOM Instruments, together with its cooperation partner Iristick, has introducedVisor-Ex 01 smart glasses for industrial use in hazardous areas. The intelligent wearable combines high camera quality and reliable communication features in an ergonomic design for the user's comfort — with a weight of just 180 g, making them the optimal solution for mobile workers for all tasks that require hands-free use as well as continuous communication. This can include many digital workflows like maintenance procedures under the guidance of a remote support expert, who can give instructions and guidance with precision seeing what is happening through the eyes of the technician. In addition, pick-by-vision is a common scenario especially in logistics.

ECOM Instruments GmbH | https://www.ecom-ex.com

Offshore-HVDC Interconnection

The Kriegers Flak Combined Grid Solution (CGS) from Hitachi Energy demonstrates a significant step forward in the high-voltage direct current HVDC Light technology. This hybrid interconnection has now been in commercial operation for a year smoothly exchanging renewable energy between Denmark and Germany. Enabled by Hitachi Energy's HVDC solution with its digital master controller system, Kriegers Flak integrates power from three offshore wind farms in the Baltic Sea. In the future, a total of four offshore wind farms – two each from the German and the Danish side – will be combined into the system. The project was co-funded by the European Union (EU) to help secure a sustainable power supply to the region. Over the past year, the Kriegers Flak system has demonstrated how HVDC hybrid solutions can optimize power grids, and offer more sustainable, flexible, and secure applications for offshore wind, to support the EU's 2050 climate neutrality targets. The hybrid HVDC Light system manages the complex task of controlling the entire Kriegers Flak CGS. By adjusting power flows in real-time, it integrates and supports the wind farms and the two asynchronous AC power grids in both countries — ensuring flexible and secure supply to European consumers. The 400 MW HVDC converter station is the enabling technology for the interconnector, which is jointly owned and operated by transmission system operators Energinet of Denmark and 50Hertz of Germany. The interconnection can provide power to 600,000 households.

Hitachi Energy | https://hitachi-energy.com

Power Line Monitoring Network

SentriSense sensor nodes attach directly to live lines and provide real-time monitoring of line and weather conditions, detecting and warning of line failures across the network. Suitable for any kind of power line up to 230 kV, and well suited to harsh and remote locations, SentriSense continuously monitors the line's position. As soon as a variation is detected, the operation center is notified of the event. SentriSense typically costs 90% less to implement than standard procedures or other detection solutions, and problems are detected 90% faster. Preventing or minimizing potential damage brings even greater savings. SentriSense provides a variety of alerts:

- Fallen cables (free fall)
- Fallen power tower (free fall)
- Fallen trees (inclination change)
- Strong winds (change in acceleration/position)
- Ice detection (inclination change)
- Alerts added remotely in mid-2022:
- Aging/corrosion/predictive maintenance (vibration changes)

After installation, SentriSense can be fine-tuned remotely to accommodate natural movements of the line. SentriSense connects to the LESS Cloud (LESS manufactures SentriSense) via cellular, Wi-Fi, or (by request) LoRa. The LESS Cloud provides secure access to data through an open API for integration with third-party systems.

P&R Technologies, Inc. | https://pr-tech.com

Utility Design Workflow Software

SPIDA Software and SBS have announced a product-level integration that connects SBS's Automated Utility Design (AUD) application with SPIDA Software's SPIDAcalc structural analysis software. This solution, based on SBS Utility DataHub, reduces overbuild and duplicate entry of utility overhead designs. It utilizes SBS's AUD software, powered by AutoCAD, to optimize network designs while validating the designs using SPIDAcalc's advanced nonlinear analysis methods. Improving system reliability and streamlining design processes ensures that unnecessary expenses and time are reduced with this powerful integrated solution. Key features include:

- Accessibility to pole loading analysis results.
- Analyze AUD design features in SPIDAcalc.
- Access analysis results from SPIDAcalc within AUD.
- Streamline design modifications.
- Easily transfer guy and anchor modifications from SPIDAcalc to AUD.
- Analysis reports.
- Generate pole loading reports from within AUD.

SPIDA Software | www.spidasoftware.com

Hard Metal Cutter

Greenlee has introduced the new ESG45LX Gator Hard Metal Cutter, a tool for the high-voltage industry, featuring an industry-first shock-load damping system that minimizes released energy while making cuts. The ESG45LX is ideal for overhead one-handed operation and cuts up to 1/2-in. Rebar (Schedule 60) and EHS Guy Strand and 5/8-in. Ground Rod and Standard Guy Strand. It has a compact, lightweight design, weighing less than eight pounds with battery, and is 33% lighter than an earlier model thanks to a redesigned flip-top style latch that reduces overall weight. Additional tool features include a double-click activation profile to avoid unintentional engagement of cutting jaw; quick-change field replaceable aluminum conductor steel-reinforced (ACSR) cutting blades to minimize downtime and connection with the Greenlee Link App to track tool performance.

Greenlee | greenlee.com

Underground Puller

The Sherman + Reilly Duct Dawg E+ is an underground puller with an electric unit capable of pulling 7,500 lbs. Its quiet all-day operation with an onboard backup generator can finish challenging pulls. This unit comes equipped with a fully-articulating, self-supporting 3-axis boom in a compact design, and a durable, battery-powered wireless remote control for safer operation. The Duct Dawg E+'s simplified underground jobsite setup, an electrically driven, twin capstan bullwheel with on-demand payout, and 3-speed gearbox delivers smooth and stable pulls. A digital recorder continually measures the length of cable deployment and line tension. Accessory storage for air adapters, duct sheaves, and tools is standard.

Sherman + Reilly | www.sherman-reilly.com

Assembly Tester

Hastings' Ground/Jumper Assembly Tester is designed to test in-service grounding and jumpering cable assemblies. Regular periodic use will ensure that jumper assemblies perform as designed for personnel safety. The tester is completely self-contained, portable, and sets up in seconds. Any standard 120-volt grounded outlet will provide power to the tester. A reference chart is provided for #2, 1/0, 2/0, and 4/0 Str. Cu. cables of specific lengths to determines correct test values. A built-in digital meter allows the operator to easily input the correct voltage specified on the reference chart for various sizes and lengths of cable. A built-in ammeter tells the operator if the assembly is in good working condition. Test electrodes are available to fit a variety of grounding equipment including elbows, grounding bushings, and ball socket clamps. Maximum voltage output is limited to protect the operator. Pressure sensitive inspection labels are available to tag cables after testing.

Hastings | www.hfgp.com

Intelligent High-Voltage Controller

The iHV is HIPOTRONICS' new state-of-the-art controller designed for AC resonant test systems, and ultra-high voltage DC systems. The iHV is included in the new test systems and available to upgrade existing systems to this modern control solution. The iHV software has a user-friendly interface designed to work in a wide-range of applications. The iHV's intuitive design and flexibility to set different test parameters allows the operator to easily and efficiently complete required tests. Features include:

- Rackmount or benchtop design to meet each customer requirement.
- Multiple measurements including output voltage, current, phase angle, ripple, and PD.
- Adjustable test parameters such as target voltage, maximum current, ramp rate, and dwell time.
- Record and view test results by saving and exporting results csv, docx or PDF.
- Meter and graph display with zoom and pan capability.
- Partial Discharge measurement integration with 3rd party PD detector suppliers.
- Auto tuning and polarity reversal for fast and accurate testing.
- Simple to Use with minimal amount of setup time and intuitive control software allows for simple testing.
- Plug & Play design with previous Windows based controllers.
- Multi-functional for use with AC or DC test systems.
- Efficient - Saved presets and sequences for repeatable accurate HV testing.
- User-Friendly HIPOTRONICS control software.
- Safe Operation with interlock and emergency stop.
- SIL 3 Compatible.

HIPOTRONICS | www.hubbell.com/hipotronics

Atchison-Holt Electric Cooperative

located in Rock Port Missouri will be seeking proposals to supply electric distribution materials as well as engineering design services as part of a FEMA approved mitigation project. For more information or to request an RFP please contact Maggie Lair at (660) 744 5344 Mlair@ahec.coop. Bid requests will remain open until COB February 28, 2022.

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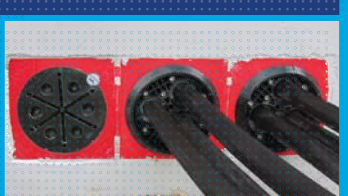

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Idaho Power

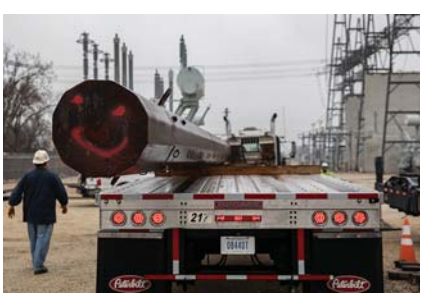
A contractor for Idaho Power responds to a distribution repair project following severe weather.

MidAmerican Energy Company

Our FAA-trained employees operate drones year-round to inspect our electric infrastructure, assess storm damage, get a bird's eye view of our wind turbines and more. They allow us to be both proactive and reactive — like catching a problem before it arises or responding to storm damage quickly after it hits.

ComEd

We're lending a helping hand to those impacted by the recent tornadoes in Kentucky by supplying poles to Big Rivers Electric Corporation. These poles will assist in the rebuilding of the energy transmission infrastructure in Kentucky as crews work to restore power in affected areas. Our thoughts go out to everyone who experienced a loss in those storms.



Tennessee Valley Authority

Did you know that TVA has been researching Electric Vehicle technology since the late 70s? Through our long-standing partnership with Electric Power Research Institute (EPRI) we developed this VW Elektrotransporter with a staggering range of 25 miles and a blistering top speed of 48 MPH. EVs have come a long way since the 70's!

Eversource CT @ EversourceCT

Signing up for the first Lineworker Certification Program at @capitalcc_ct back in June of 2021 was all part of Shafqat Rahman's plan to take his experience in the electrical field to the next level. "I'm looking forward to working with highly trained people, and being part of this great industry," he said. And now, he's doing just that! After graduating in August, Shafqat works for Eversource as a line helper.

Ameren Corporation @ AmerenCorp

Thanks to everyone who joined us for the Ameren Thanks for Giving Parade. In case you missed it, there's still time to help fight food insecurity in our community with a donation to @STLFoodbank.

AD INDEX

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The Future of Grid Infrastructure Development

As 2022 begins to unfold with the Bipartisan Infrastructure Law passed, challenges and opportunities abound in almost equal measure. As a federal transmission infrastructure organization, we are undertaking a dialogue this year to explore what lies ahead in a time of dizzying change. Western Area Power Administration is part of the Department of Energy, yet we are also a utility in the business of marketing and delivering cost-based power from 57 hydropower plants across a15-state and 17,000+ circuit mile high-voltage transmission system footprint. We deliver power to more than 700 preference customers who in turn provide retail electric service to more than 40 million consumers.

Our core mission as a federal business remains to steadfast: deliver cost-based federal hydropower and transmission services. As we stand at the precipice of a new year, there are a troika of challenging issues facing WAPA and the West: weather, markets, and infrastructure investments. More specifically, for WAPA, these issues mean operating through extreme weather impacts and debilitating drought, evolving energy market constructs emerging from all directions, and a historic push on transmission infrastructure investments. Some of these matters can get existential quickly.

Legacy in the Wake of Extreme Weather

Today, an internet search of 'western U.S. drought' populates with about 84 million search engine results, confirming what is common knowledge now for most. Drought and extreme weather are impacting water deliveries and hydropower generation. These affect every part of our business, from rates to supplemental power purchasing to transmission resiliency.

Several of our projects have experienced severe and enduring drought since 2000. Our Colorado River Storage Project system's largest reservoir Lake Powell, only received a fraction of its normal inflow in 2021 and is about 27% of full capacity. This is the lowest level since being filled. Forecasts show significant possibilities that Lake Powell will drop to an elevation from which power cannot be generated. Simply put, WAPA can only deliver hydropower that is generated. From an operational standpoint, those existential questions begin to emerge.

Other weather issues have inspired increased planning and operational approaches, such as extreme fires and last year's polar vortex. Proactive approaches and coordination with generating agencies and customers have born near-term results, from enhanced operational plant efficiencies to state-of-the-art vegetation management and easement access permitting. WAPA is ready to engage, particularly as technology is constantly emerging and maturing from our national lab partners. We all need to find the right fit to implement comprehensive and longer-term solutions addressing system resiliency to manage climate impacts. It is also important to note that the 700 customers we serve (and the communities in which we all operate and live) represent a huge swath of the West, which is often underserved, economically distressed and rural.

Markets. Markets! Markets?

A similar search today for 'western wholesale electricity markets' comes up with only 15 million search engine results. On any given day, a meeting or new organization is emerging to explore market constructs and scenarios like real time, day ahead, and regional transmission organizations. This may not be true, but it feels true. As an active member of the public power universe that is not jurisdictional to state or federal regulatory oversight, these are sometimes tricky conversations. As a business utility, these are crucial conversations.

In 2021, WAPA went live in both the California Energy Imbalance Market and the Southwest Power Pool's Western Energy Imbalance Service market. And we are exploring other market constructs. The role of maintaining the value that hydropower brings to these market services and organizations is our North Star. Like our counterparts, we also need efficient markets to ensure access to affordable supplemental power and services. Added to our complexity is our geographical diversity and footprint. What might work for some may not work for others, so we have taken a one-size-does-*not*-fit-all approach.

Infrastructure Development, Investment Opportunities

Managing WAPA's expertise and resources is top priority when it comes to system operations, maintenance and already planned construction projects. In addition, long-held relationships enable us to develop and permit infrastructure projects when needed. This is also part of our core mission. With our ubiquitous presence in the West, private-sector transmission investors and developers are increasingly engaging with us to identify opportunities to interconnect or tap our infrastructure development expertise and resources.

I believe in public-private partnerships. It's what first brought me to WAPA to run our $3.25-billion infrastructure loan program. We have leveraged partnerships and leverage expertise to bring infrastructure projects to reality without compromising customer priorities. And we are coordinating with DOE to leverage bipartisan infrastructure bill resources for projects that support resiliency and renewable energy deliveries.

WAPA knows high-voltage transmission. Our mission to transmit clean hydropower benefits underserved, tribal, rural, and economically distressed communities resonates deeply with everyone at WAPA, from engineers to environmental scientists and from administrative support to linemen. Clean infrastructure is our passion. TDW

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