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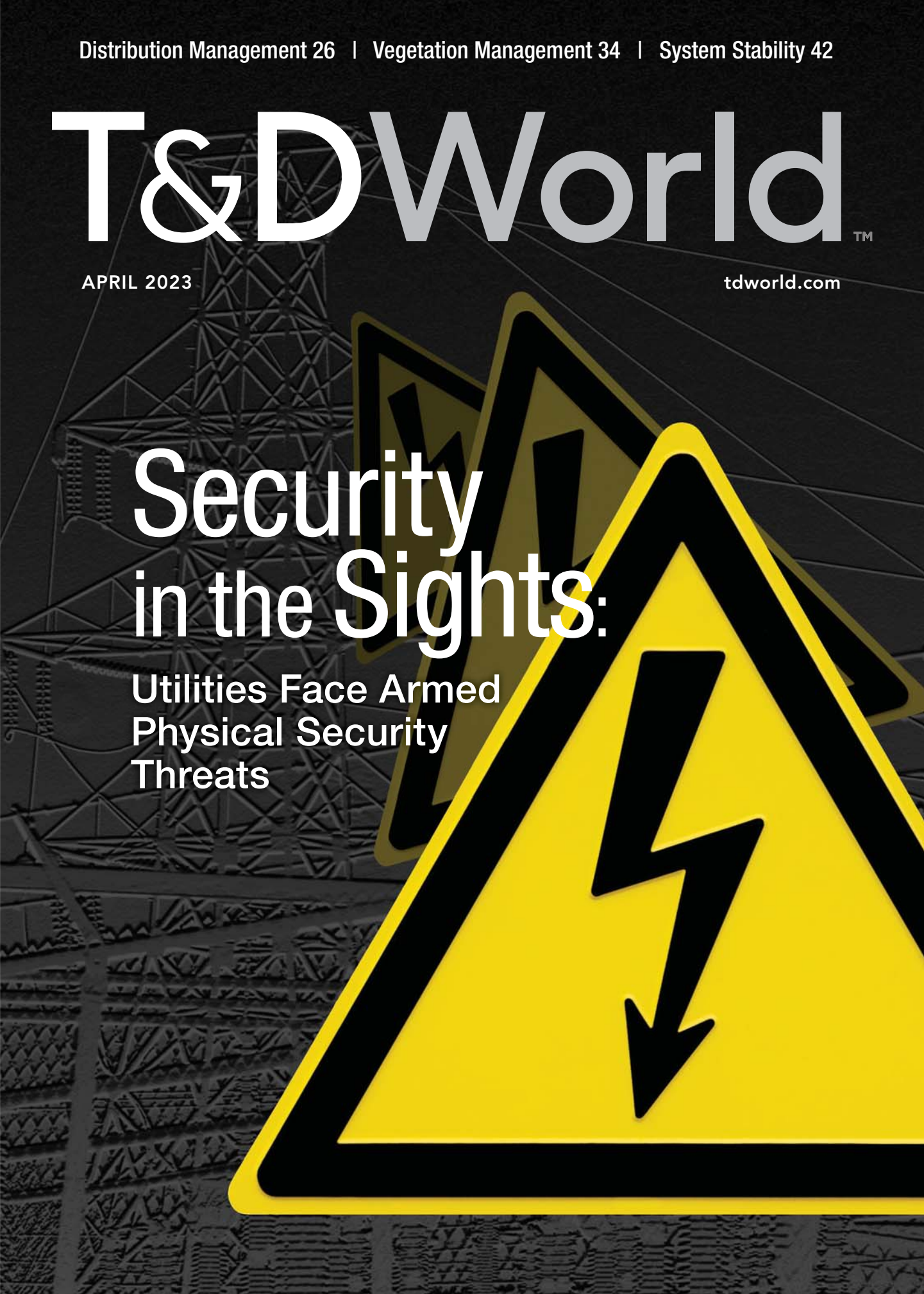

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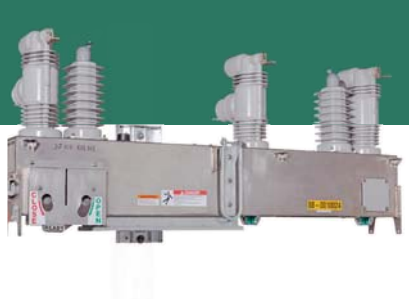

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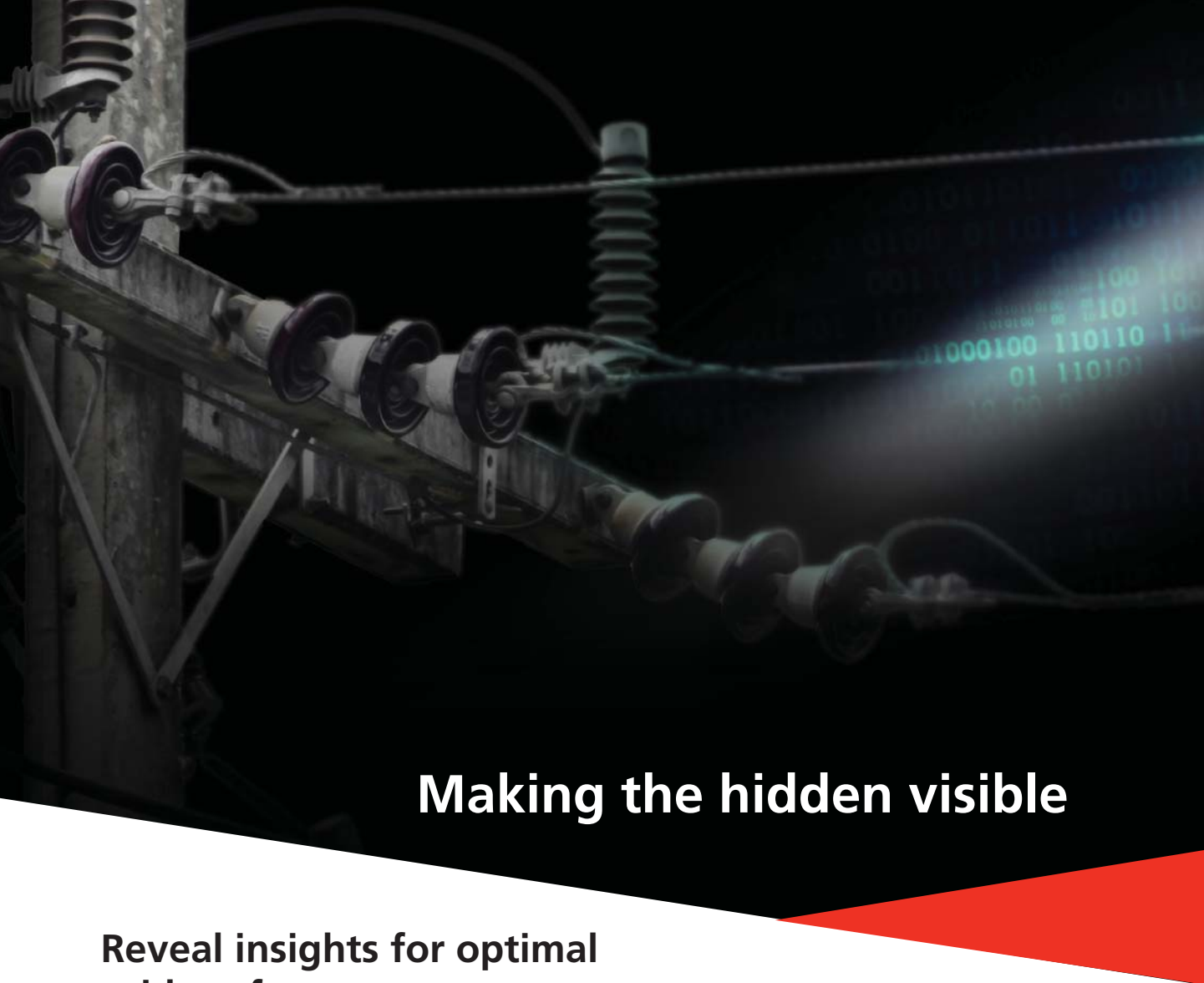

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GRID SECURITY

By **JEFF POSTELWAIT**, Senior Editor

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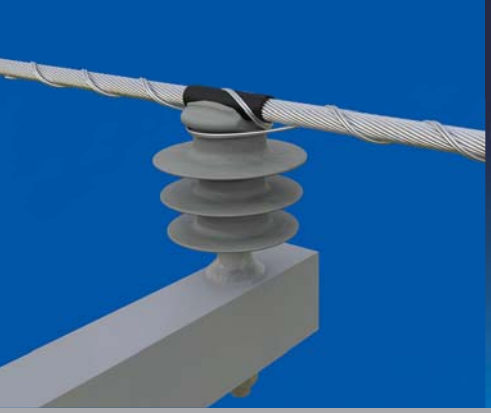

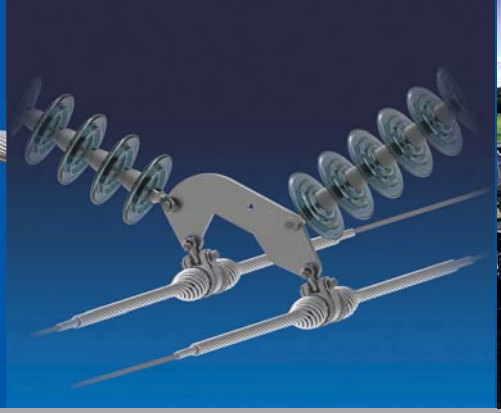

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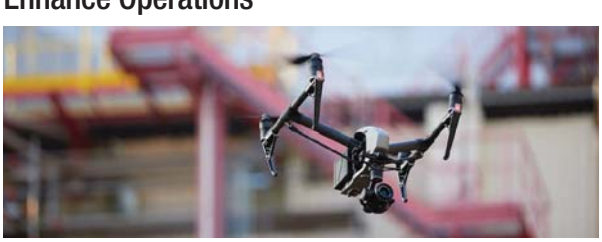

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Proving the Point: DOE Study Supports Calls for Transmission Upgrades

I've written a few columns in the past focused on challenges transmission grid owners and operators face and the dire need for investments and upgrades. For the U.S. transmission system to support electrification and the transition to a low or no carbon future, action must be taken soon. This isn't just my opinion or that of experts much smarter than me, this statement is backed up by the U.S. Department of Energy (DOE). In late February, the DOE released its second draft of the National Transmission Needs Study that reveals the various needs in 13 regions of the country. Those needs include improving reliability and resiliency, alleviating congestion, relieving high-priced areas, adding delivery capacity and more.

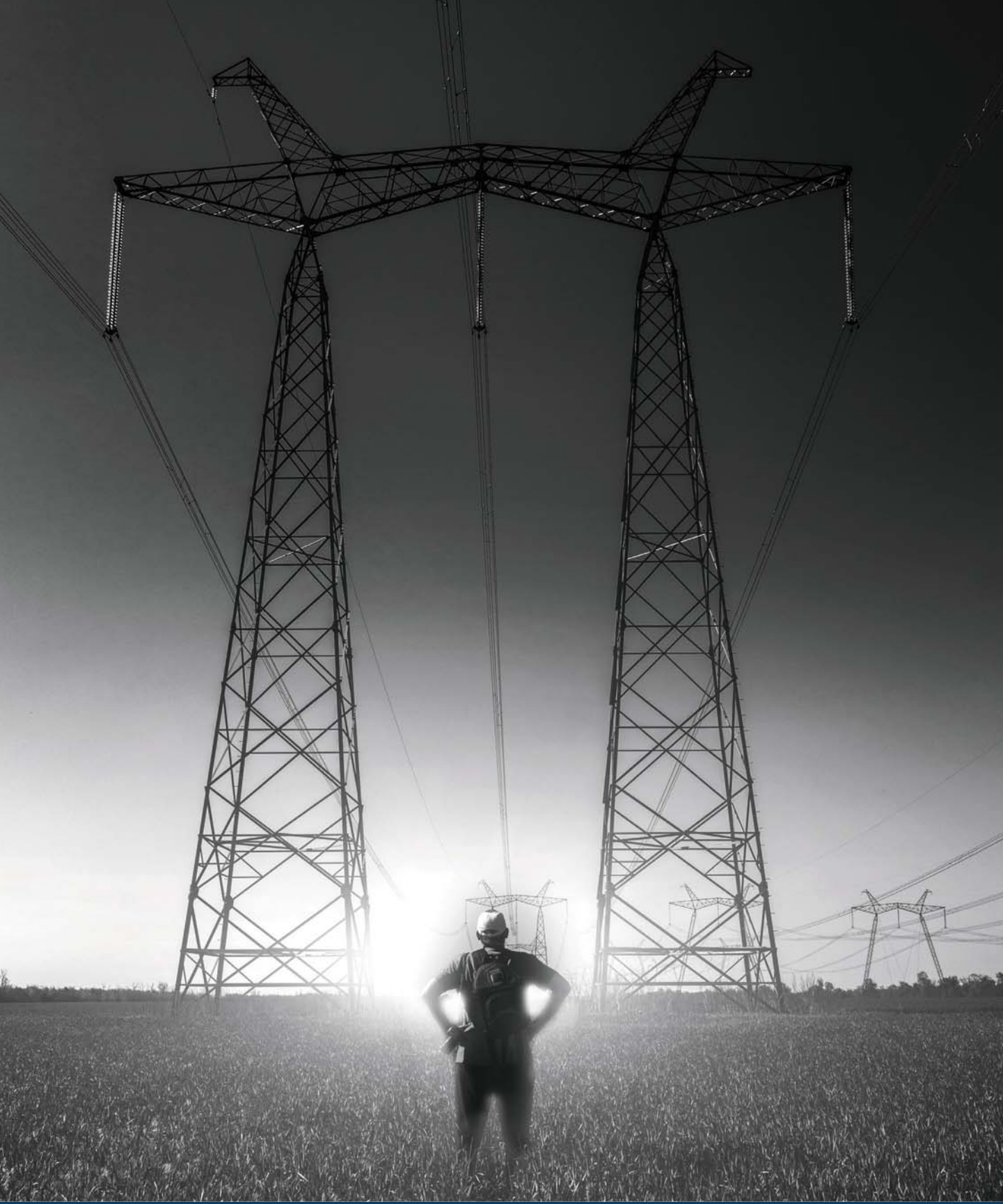
One of the study's main purposes is to help the DOE decide where to focus transmission infrastructure funding that's available through the Infrastructure Investment and Jobs Act, signed in late 2021, and the more recent Inflation Reduction Act, signed in August 2022. Because this study will impact funding decisions, I'm using this month's column to highlight some of the study's major findings. This latest version of the Needs Study is 191 pages long, and although I didn't read the entire study, I looked closely at the high-level findings for each region and created a table to illustrates those findings.

The study reveals 10 major "needs," with the most common being "increase transfer capacity with neighboring regions to meet projected generation and load growth." This need showed up in 11 of the 13 regions. Texas and the Midwest are the only regions that avoided it. A couple of other major needs are "improve system reliability and resilience" and "increase transmission deployment/capacity within region to meet projected generation and load growth." These needs appeared nine times under various regions' assessments.

It's important to note the DOE doesn't intend for this study to "prescribe" solutions or recommendations to the needs it uncovered. The DOE says instead its purpose is to "establish findings of need in order for industry and the public to suggest best possible solutions for alleviating them in a timely manner." According to the study, an electric transmission need is an "existence of present or expected electric transmission capacity constraints or congestion in a geographic area."

I suspect most transmission system owners and operators, including electric utilities, had already identified many of the things uncovered in this study, at least for their own systems. It's valuable for them to see the similarities and differences among other regions. too. This information could provide insight into how owners and operators can improve not only their own systems but also how they can work with other owners and operators to impact systems outside their operating areas. This is important because preparing and upgrading the U.S. transmission grid will require cooperation and collaboration among many entities. You can read more about this report on page 15 and find the entire report at *https://www.energy.gov/sites/default/files/2023-02/022423-DRAFTNeedsStudy-forPublicComment.pdf.* TDW

Regions >	California	Northwest	Mountain	Southwest	Texas	Plains	Midwest	Delta	Southeast	Florida	Mid-Atlantic	New York	New England
Needs Identified (below)													
Increase transfer capacity with neighboring regions to meet projected generation and load growth	x	x	x	x		x		x	x	x	x	x	x
Increase transmission deployment/capacity within region to meet projected generation and load growth			x	x	x	x	x	x	x	x	x		
Improve system reliability and resilience	x	x	x	x	x	x	x			x			x
Relieve high-priced areas by providing access to low-cost generation	x						x				x	x	
Alleviate congestion within the region							x				x	x	
Increase transfer capacity with neighboring regions to alleviate transfer limits			x		x		x						
Alleviate unscheduled flows with neighboring regions	x	x											
Alleviate unscheduled flows along paths within region			x										
Alleviate transfer capacity limits with neighboring regions							x						
Deliver new, cost-effective generation to high-priced demand						x							



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Did Duke Energy Just Change the Game for Community Microgrids?

Duke Energy received a lot of attention earlier this winter for powering an entire town — Hot Springs, North Carolina — with a microgrid. But the project's real significance may lie in demonstrating a technology breakthrough that could open a new door to green energy for other communities.

First, some background. A remote mountain town of about 500-600 people, Hot Springs, gets power from the electric grid via a 10-mile, 22.86 kV feeder prone to extended outages.

Duke Energy — the town's utility — considered building a second feeder line to fix the problem but determined that a microgrid made more sense because, unlike a new line, the microgrid would not disrupt miles of scenic and environmentally sensitive terrain. The North Carolina Utilities Commission agreed and approved the microgrid in 2019.

Hot Springs Microgrid at a Glance

- 2 MW alternating current solar
- 4.4 MW lithium-based battery storage
- GEMS Digital Energy Platform by Wärtsilä
- Acts as backup to the 10-mile distribution feeder line
- Provides reliability services to the electric grid, such as frequency and voltage regulation and ramping support and capacity during system peaks.

What Duke was trying to do technologically — the breakthrough — had worked in lab settings but never before in a commercial microgrid, as far as Duke could discern. The complexity of the Hot Springs project, combined with Covid-related supply chain disruptions, led to a slow, four-year build-out of the microgrid.

"We had to be very careful, very calculating because we wanted this to work the first time, and it has. And that's what we're most proud of," said Jason Handley, general manager of Duke's Distributed Energy Group.

The Breakthrough

What was it that Duke Energy achieved? Creation of an inverter-based community microgrid that is capable of black start. In other words, running only on solar and batteries, the community microgrid can restart following a power outage without help from a fossil fuel generator or the electric grid.

As Handley sees it, this approach makes sense for the growing number of communities like Hot Springs that want reliable electricity but also want to minimize their carbon footprint. The utility saw Hot Springs as a proving ground and now plans to build inverter-based community microgrids elsewhere in its service territory, which includes North Carolina, South Carolina, Florida, Indiana, Ohio and Kentucky.

"There are going to be other opportunities for us to do this in some of our coastal territories, some of our other mountainous territories and even potentially in downtown areas where they don't want the noise. To be quite honest, generators make noise," Handley said in an interview with Microgrid Knowledge.

What Sets Hot Springs Apart

A microgrid in the Western Australia town of Onslow achieved a similar accomplishment — powering the town on all renewable energy. Still, according to Handley, it did not do so from a black start position, which sets the Hot Springs microgrid apart.

"We literally opened the switch at the substation and killed the line. Everything went dead. And then we brought everything back up," Handley said. "The battery came back in grid forming mode, setting the voltage, setting the frequency. And, then the solar inverter came back in grid following [mode]."

Duke phased in the process of activating the microgrid, using sectionalizing reclosers "Blackstart is unique. Inverters have tight current limiting behavior. They do not react well to cold load pickup and magnetic inrush. So they have limitations," he said.

To resolve the problem, Duke activated the energy through multiple reclosers, just as it would during a power outage on the distribution system. "So we would close one switch, absorb that inrush, and allow the fluctuation, wait another minute, close another switch until we pick up the entire town," he said.

Safety was a big concern and also the reason the project was slow to bring to fruition.

"The project actually had to go through a couple of different iterations from the standpoint of ensuring that we had the right protection and control settings for an inverter only based microgrid because this is the first one that we've really done," he said.

More Inverter-based Microgrids Coming

Following the success of the Hot Springs microgrid, Duke plans to bring inverter-based microgrids to projects in Indiana and Florida.

In Indiana, the technology will be applied at the Indiana National Guard Camp Atterbury training operation in Johnson County and a substation in Nabb.

In Florida, Duke Energy plans to install the inverter-based microgrids at sites in Jennings, Micanopy and Trenton, as well as at a middle school campus in St. Petersburg that will serve as an emergency shelter.

The utility learned some critical lessons in building the Hot Springs microgrid, but they weren't all technological, according to Handley. The project also demonstrated how meaningful building relationships and spending time with the community is to a project's success.

"I cannot thank the mayor of Hot Springs, the sheriff, the town council enough. They have been great to work with. They've been patient with us over the years," Handley said. "I think that we have a really good relationship, and I hope to use this as a stepping stone for our other communities as we move forward." TDW

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Making Transmission Cool

It's spring, and I sure have been looking forward to the end of winter. The temperature is rising, the tulips are getting taller, and my virtual inbox is flooded with news of technological developments popping up on the power grid. I always look forward to the spring bumper crop of press releases, and it has been a busy winter. One from Con Edison felt special because it fit nicely with my January 2023 editorial about growing pains in the supply chain.

That editorial focused on how the supply chain is impacting many utility solar projects and customer projects are becoming more important. Con Edison reported that its customers made 2022 a record year with solar installations. It completed 9,600 solar projects with a capacity of 89 megawatts (MW) in 2022. Con Edison went on to say when 2022 was combined with previous years, its customers have installed over 487.32 MWs behind-the-meter. It's amazing what a utility and its customers can do when they work together!

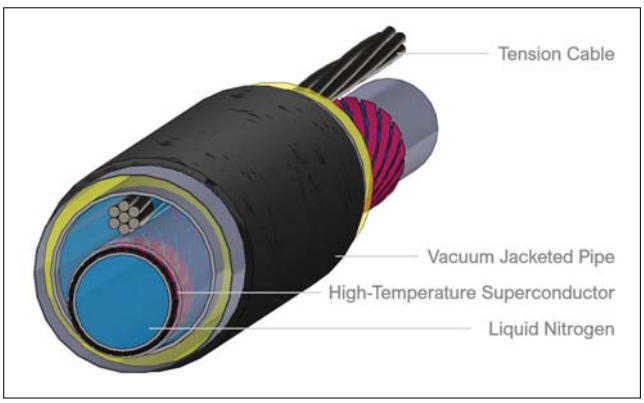
Another release had a personal link for me. It was from a cryogenic company, VEIR. It was about its latest developments in high temperature superconductors (HTS). Cryogenics is a fascinating technology and the HTS area offers many applications relevant to the power delivery system. They range from energy storage to power delivery and a lot of other topics that are improving the power grid.

HTS Memories

As I read this release I thought about a HTS project I had been involved with several decades ago. It was one of those "never been done before" projects and I could never resist that type of challenge. If you're not familiar with cryogenics, superconducting technology is one of those technologies that has been around for a long time. However, it needed materials science to catch up with the theory before it could make the jump from the laboratory and to the power grid.

The development of HTS materials was that breakthrough. Materials were discovered that allowed superconducting to take place near the boiling point of liquid nitrogen, –320.4°F (– 195.79°C), rather than near absolute zero. And that's as deep as I'm going into the physics. It was dubbed high temperature superconducting, and a lot of demonstration projects popped up in the power industry.

My exposure came about when a HTS cable manufacturer contacted the utility I worked for with a proposal. They wanted to modify the utility's back-to-back HVDC (high-voltage direct current) converter station with HTS cabling inside the valve hall. The HTS cables would be an HVDC transmission line running between the two sections of the back-to-back converter.



HTS Cable Illistration. Courtesy_of_VEIR.

The project had a lot of support, and my utility agreed to it. Unfortunately, as we moved forward we identified a lot of expensive modifications that were needed for both the converter station and the HTS facilities. These modifications hadn't been anticipated and were beyond the manufacturer's budget. It was back to the drawing boards for the manufacturer and several years later many successful HVDC demonstration projects took place.

HTS Today

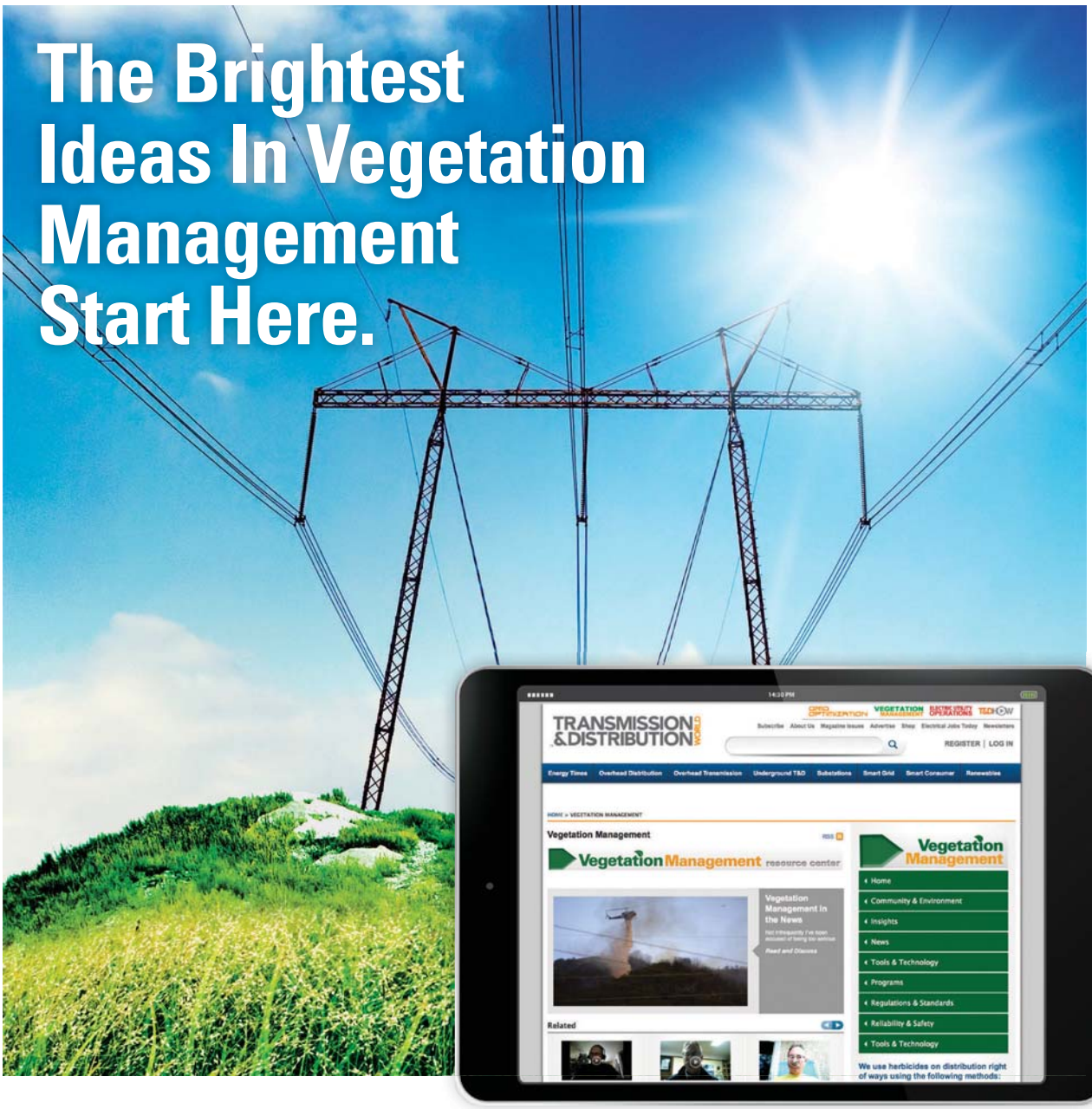
With that in mind, this release got me thinking about cryogenics once again. I wanted to find out more about what was taking place, so I talked with VEIR's chief executive officer, Tim Heidel about their unique approach to HTS cabling. He explained, "VEIR's system allows for higher currents at lower voltages, which can result in smaller rights-of-way. It could provide 5 to 10 times the capacity of conventional transmission lines."

When asked how the VEIR system compared to other HTS methods, Heidel said, "Traditional HTS cabling uses underground closed-loop systems. VEIR uses an open system with evaporative cryogenic cooling to keep the superconducting material cold for its entire length. This is a simpler system that is lighter and can be used for overhead transmission."

We continued our discussion. Heidel said, "In December 2022, VEIR completed an end-to-end demonstration of its core technology. A 100-foot (30 meters) span of VEIR's cable system was suspended on steel towers in the lab. The test span was successfully operated at 4,000 amperes – a first ever for an overhead superconducting transmission line." Heidel and I promised to stay in touch and see where this new application will take HTS overhead transmission in the future.

With highway and railway rights-of-way being shared with transmission lines, reducing the space required for those lines and increasing their capacity is a critical element in renewable integration. HTS is poised to be a major contributor for these characteristics! TDW

The Brightest Ideas In Vegetation Management Start Here.



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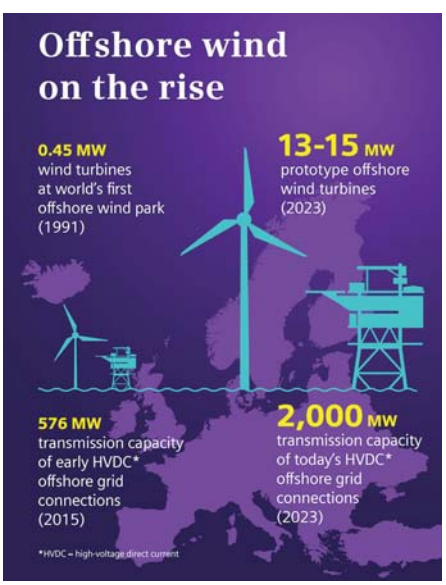
Extending The Power Grid's Boundaries With HVDC-VSC

Integrating gigawatts of offshore power requires all the technological parts working together harmoniously.

Have you noticed how the technologies associated with renewable generation are working together? Energy storage is a key element for solar and wind generation. Grid-forming inverters are a critical component for these two renewable energy sources. But it's HVDC (high-voltage direct current) VSC (voltage source converter) technology that's moving offshore wind generation into a new era. HVDC-VSC is playing an important part in moving enormous blocks of power extreme distances as all of these pieces of technology come together.

Offshore wind farms have taken renewable energy enthusiasts by storm in North America, but with only two operating offshore wind farms, it's more about the potential. The Asia-Pacific region's offshore wind is growing substantially, however the European Union (EU) is attracting most of the attention. Many experts are talking "game changer" when it comes to offshore power production, which shouldn't be surprising. After all the first offshore wind farm became operational in 1991 about one mile (2 km) off the Denmark coast. It had 11 turbines with a capacity less than 5 megawatts (MW), and the power grid was never the same.



Courtesy of Siemens Energy.

Over the next couple of decades, the capacities of individual offshore wind farms grew to hundreds of MWs, but today's wind farms are starting to move into the realm of gigawatts (GW). As these behemoths grow in size, they are moving further offshore taking advantage of the higher sustainable winds found there. That, however, complicates connecting them to the grid because of the tremendous distances involved. There was also the issue of the sheer amount of power coming on shore.

Pushing the Envelope

Initially, offshore wind farms used alternating current (AC) technology to bring their power onshore, but there are limitations with AC technology. Without going into a lot of detail, the longer the AC cables become, the higher the charging currents become in the cables. This limits the distances that AC submarine cables can be utilized because of the reactive compensation needed.

On the other hand, HVDC VSC technology has no distance limitations, and they are more efficient at transporting larger blocks of power. So, it should not come as a surprise that developers are using more HVDC-VSC technology when it comes to connecting the onshore grid to these distant wind farms.

Last year, Ørsted announced it had awarded Hitachi Energy a contract to provide two HVDC-VSC systems to connect the 2.85 GW Hornsea 3 wind farm to the United Kingdom's (UK) power grid. Hornsea 3 is located roughly 99 miles (160 km) off the Yorkshire coast. It will have more than 200 wind turbines and cover almost 270 sq miles (700 sq km) It is scheduled for commissioning in 2027. The Hornsea 3 is a significant step toward the UK's goal of deploying 50 GWs of offshore wind generation by 2030.

Earlier this year, the German transmission system operator Amprion awarded a contract to the consortium of Siemens Energy and Dragados Offshore to build HVDC-VSC systems for two offshore grid connections in Germany. Each grid connection will transport up to 2.0 GW of offshore wind power to the onshore power grid. Their combined transmission capacity of 4.0 GW will connect several wind farms in the North Sea to the German transmission grid. They are expected to be in service as early as 2029 and 2030 respectively.

These systems will be used by the BalWin1 and BalWin2 (formerly LanWin1 and LanWin3) grid connection projects. Each system is designed to move the renewable offshore energy to the German power grid via separate HVDC submarine/underground cable systems. These two cable systems are approximately 242 miles (390 km) in length. The land-based HVDC-VSC stations are being built near Wehrendorf in Lower Saxony and Westerkappeln in northern North Rhine-Westphalia.

Dragados Offshore is responsible for the construction and offshore installation of the associated German North Sea platforms. Siemens Energy's scope of supply consists of the complete equipment for two HVDC-VSC systems on the platforms in the North Sea and two associated HVDC-VSC stations

onshore. Siemens Energy will also maintain the HVDC-VSC systems for 10 years.

A Deeper Dive

These sophisticated HVDC-VSC offshore/onshore systems have a high degree of complexity that isn't easily understood. With that in mind, "Charging Ahead" went to a specialist. We spoke with Hauke Jürgensen, senior vice president Grid Solutions at Siemens Energy to get an expert's perspective of what is taking place with the technology. Jürgensen started off saying, "When Germany started utilizing offshore wind farms about 2010, the generation capacities were only in the hundreds of megawatts and closer to shore."

Continuing, Jürgensen said, "Today, however, there are approximately 8.1 GWs of offshore wind generation connected to the German grid currently, and it's further from land adding additional layers of difficulty. Also, Germany's "Offshore Wind Energy Act" has increased the goals with a target of connecting 30 GW of wind generation to the grid by 2030. That is a very ambitious timeline, and it requires taking advantage of all the current technology available while developing additional innovative approaches to make it happen."

BalWin1 and BalWin2 offshore grid connections to Germany.
Courtesy of Siemens Energy.

Jürgensen stated that, "Siemens Energy's approach for the BalWin1 and BalWin2 grid connection projects represents a distinctive philosophy to increase the scale of HVDC transmission schemes. This advancement is based on proven 900 MW HVDC-VSC platform technology found in previous Siemens Energy projects. By utilizing a bipolar configuration design, the new systems can be operated at twice the voltage and transmit twice the power. For these grid connections projects that represents an increase to 2.0 GW in each systems' transmission capacity, but more is needed."

Jürgensen explained, "By designing these offshore HVDC-VSC platforms to function as HVDC interconnection hubs (editor's note, artificial energy islands), there would be increased flexibility for moving offshore power to where it's needed. This would provide a multi-terminal HVDC mesh grid, but one thing is crucial for this. This approach is going to require all the manufacturers of HVDC-VSC systems to work together."

He continued, "Current HVDC-VSC schemes still are somewhat proprietary "black-box" systems. A system from vendor "X" does not immediately work with equipment manufactured by vendor "Y" and vice versa. There isn't the ability for mix and match systems, but that is about to change. In January 2023, the EU kicked off the InterOPERA project to make future HVDC systems mutually compatible and interoperable by design. A crucial requirement needed to realize a meshed DC grid and to bring renewables even more efficiently to the load centers."

Jürgensen concluded, "The multi-terminal technology itself has progressed quite far, but it will take some time for the industry to do the necessary research and development and especially to agree on the best possible technical standards for multi-vendor HVDC schemes. Siemens Energy is going to be very proactive in this process. HVDC is a key technology in a decarbonized energy landscape, and we are facing correspondingly ambitious grid expansion plans."

Continuing, "At the same time, renewable energy projects worldwide continue to suffer from challenges such as long lead and approval times or an increasing shortage of skilled workers and engineers. We have every means at our disposal to overcome the challenges, but business, politics and society must work closely together so that current technologies can be deployed in the most efficient way and at the same time innovations can be driven forward. The introduction of technical standards that enable the interoperability of HVDC networks from different suppliers is just one building block that brings us closer to reaching climate targets."

Critical Technology

Multi-terminal technologies are also important to another cutting-edge application known as artificial energy islands. Interest is growing in the EU and there have been several projects announced lately to build islands in the North Sea and the Baltic Sea. One such comes from Belgium's transmission service operator Elia. They plan to develop a multi-functional artificial energy island in the North Sea approximately 28 miles (45 km) off the Belgian coast. The island will be an electricity hub connecting wind farms and European countries.

Another comes from Denmark. They are building two energy islands. One will be built on Bornholm Island in the Baltic Sea. The other will be an artificial energy island built approximately 62 miles (100 km) from the Danish mainland in the North Sea. Wind Europe reported that Germany and the Netherlands are also working on energy islands. They indicated that energy islands will play a "huge role in Europe's future energy system."

The latest EU offshore wind energy target for 2030 is 60 GWs and that's expected to be revised upward and figures like 450 GWs are being kicked around for 2050. HVDC-VSC, interoperability, mesh-grids, artificial energy islands, and other advanced technologies are going to play a critical part in meeting the EU goals. It's like a technological jigsaw puzzle with all the pieces finally falling into place to have the power grid extended offshore! TDW

AEP STRIKES $1.5B DEAL TO SELL UNREGULATED RENEWABLES

A consortium of firms led by Invenergy LLC has agreed to buy American Electric Power Co.'s unregulated renewables portfolio, which spans 14 projects in 11 states, in a deal worth $1.5 billion.

Columbus-based AEP brought its contracted renewables group to market a year ago and its executives had initially targeted late summer for a sale of the portfolio, which comprises 1,365 megawatts (1,200 of them wind). The sale to IRG Acquisition Holdings — which includes Quebec pension manager CDPQ and some Blackstone Infrastructure funds in addition to Chicago-based Invenergy — is expected to close by June 30 and should net AEP about $1.2 billion in cash.

Paul Hamilton/Getty Images

The renewables sale is one of two key transactions recently named President and CEO Julie Sloat is looking to close so her team can reassess AEP's need to raise money from investors to fund its long-term plans to add more than 15 GW of renewables to its portfolio. The other is the planned sale of Kentucky Power to Algonquin Power & Utilities Corp., which was initially turned down by federal regulators in December but for which the two companies recently submitted new filings. If completed, that sale also should bring in about $1.2 billion.

"We want to make sure we have a strong balance sheet because we don't want anybody worried about any dilutive otherwise actions that we would have to take," Sloat told analysts on a conference call discussing AEP's quarterly results about these deals' potential benefit.

AEP posted a fourth-quarter profit of $384 million, a big drop from the $539 million of the last three months of 2021, as revenues rose to $4.9 billion from $4.1 billion. Taking out a $100 million expected loss on the Kentucky Power sale and nearly $24 million in asset impairments and other charges, operating earnings climbed to $540 million versus $496 million in the prior-year quarter.

During the quarter, normalized residential sales fell 0.8% from late 2021 while commercial sales climbed 5.4% and industrial sales rose 1.5%. Those numbers combined to help give AEP total normalized sales growth of 2.8% for the year — the company's highest since the late 1990s — but new CFO Ann Kelly told analysts the company expects that number to fall to 0.7% in 2023 and 1.0% next year. Residential sales this year are forecast to slip 0.5% while commercial growth is expected to slow to just 0.6% but industrial activity is forecast to grow more than 2%. ■

DRAFT DOE STUDY IDENTIFIES PRESSING NATIONAL ELECTRIC TRANSMISSION NEEDS

The U.S. Department of Energy's (DOE) Grid Deployment Office (GDO) has released a draft of the National Transmission Needs Study for public comment and feedback. Updated by President Biden's Bipartisan Infrastructure Law (BIL, Section 40105), the Needs Study provides information about present and anticipated future capacity constraints and congestion on the nation's electric transmission grid and serves as DOE's triennial state of the grid report. Findings of the Needs Study will provide public insight into areas of the power grid that would benefit from increased transmission capacity.

In October 2022, an initial draft of the Needs Study was released to states, tribes, and regional grid entities to ensure regional, interregional, and national perspectives are taken into consideration. DOE received nearly 180 comments from 20 different entities and that feedback has been incorporated into the second draft. DOE is requesting feedback on the Draft National Transmission Needs Study, specifically on the analysis used, conclusions, or any other comments or suggestions for improving the study.

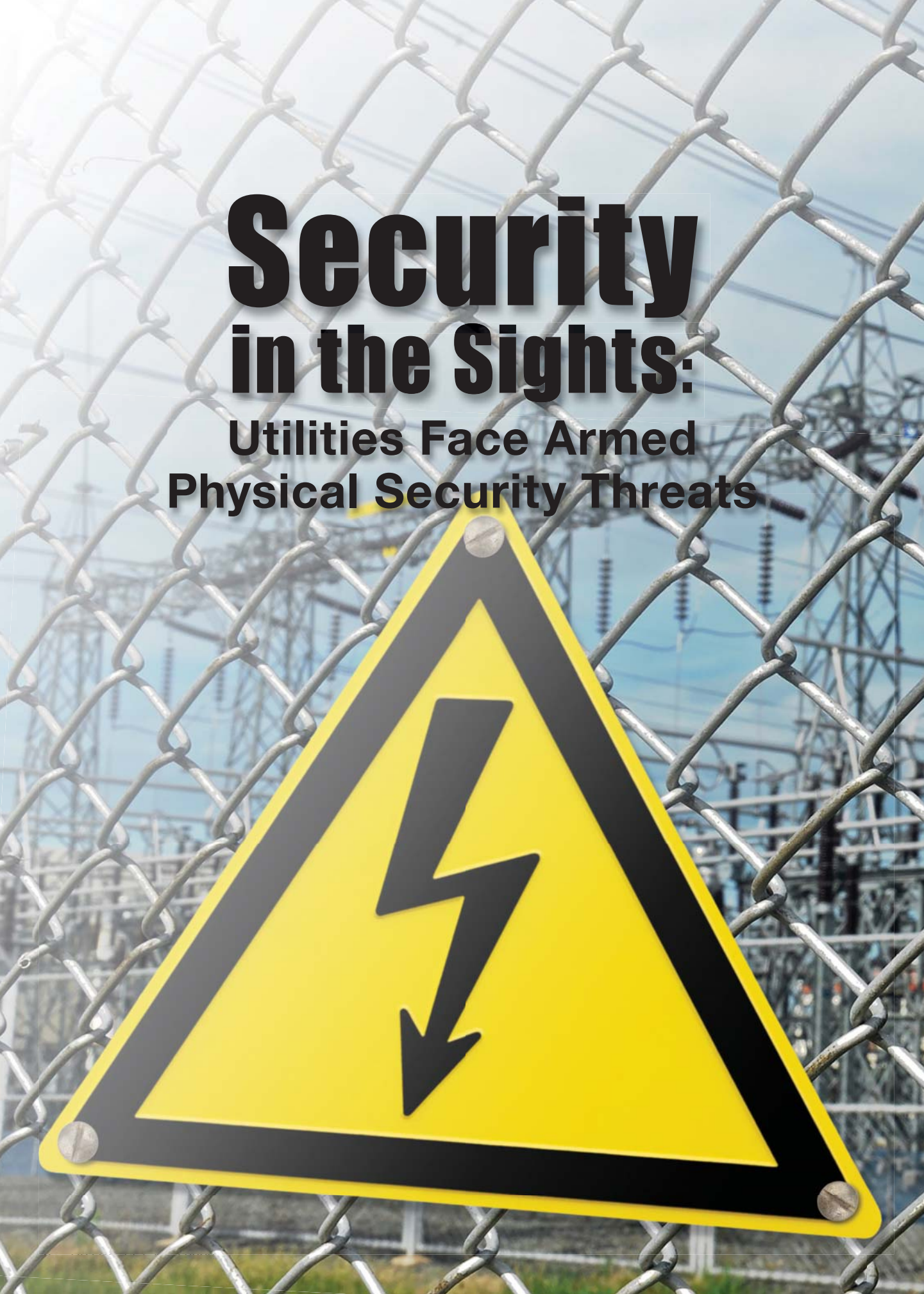
DOE launched the Needs Study in January 2022 as part of the Building a Better Grid Initiative, which aims to catalyze nationwide development of new and upgraded high-capacity transmission lines and support investments to modernize the flexibility of the distribution system to create a more resilient electric grid. The Bipartisan Infrastructure Law expanded a previous DOE state of the grid report, called the National Transmission Congestion Study, to consider both historic and anticipated future capacity constraints and congestion that could adversely affect consumers. The Needs Study contains no new modeling and is an assessment of existing data and the results from power sector reports published by a variety of sources in the last several years.

Importantly, the Needs Study is not a long-term planning study. The draft findings do not identify any particular transmission solution for the identified needs. While the Needs Study is an input to the potential designation by DOE of National Interest Electric Transmission Corridors (NIETCs) under section 216 of the Federal Power Act, the draft Needs Study does not designate or identify any specific NIETCs. Any such designation will occur in a future separate process.

The Needs Study is one of two transmission studies that GDO will release in 2023. The second is the National Transmission Planning (NTP) Study; a national-scale, long-term (a 15- to 30-year) transmission planning analysis will identify a portfolio of potential transmission solutions that will enable a national transition to clean energy production and delivery. The NTP Study will inform existing regional transmission planning processes and pinpoint strategies to accelerate decarbonization while maintaining system reliability. ■

Security in the Sights:

Utilities Face Armed Physical Security Threats



Industry voices answer the questions: What kind of person shoots at an electric substation, and why? And what can be done about it?

By JEFF POSTELWAIT, Senior Editor

Back in March 12, 2014, the *Wall Street Journal* ran a piece about the risk of a far-reaching, long-lasting power outage in the U.S. if the power grid were sabotaged at just a handful of vulnerable spots. The basis of the report was a study done by the Federal Energy Regulatory Commission that was shared with Congress, the White House and industry officials, but was kept private from the public.

Industry reaction to the *WSJ* report was intense. Then-Acting Chairwoman of FERC Cheryl LaFleur said the report was "highly irresponsible." Then-Sen. Lisa Murkowski (R-Alaska) called for the Energy Department's Inspector General to look into how the newspaper obtained the information it published. A release from the Edison Electric Institute quoted its president, Thomas Kuhn, as saying FERC, Congress and the administration should investigate the disclosure.

As a reporter who writes about the energy sector, I'm of two minds on this. I understand why, then and now, talking about power grid vulnerabilities publicly is going to upset some. I do not think talking about a problem makes it more likely to happen. I was taught in journalism school that where there are systems that aren't working the way they should, it should be investigated and discussed.

At the same time, the power grid is seeing an uptick in attacks, and this is a scary thing for everyone who uses electricity. That is to say, everyone.

Physical attacks on the power grid are at their highest level since 2012, according to federal records examined by Politico. This includes 101 physical or computerized attacks reported from August 2022 to December 2022.

In one major incident, two Duke Energy substations in Moore County, North Carolina were shot at, which caused power outages affecting about 45,000.

Another attack came Christmas Day when four substations operated by Puget Sound Energy and Tacoma Public Utilities, touching off an outage affecting 14,000 customers.

"Is there something more sinister going on?" Richard Glick, then-chair of the Federal Energy Regulatory Commission, wondered aloud at a December 2022 press conference. "Are there people planning this?... I don't think anyone knows that right now. But there's no doubt that the numbers are up in terms of reported incidents."

It is difficult to talk about incidents like these, which appear as though they could be coordinated in some way, but may not in fact be part of any larger, more nefarious plan. You risk doing a terrorist's work for them, speculating beyond what the evidence shows.

"Are we going to have armed guards at every substation, every transformer in the country, in order to make sure this doesn't happen?" FERC Commissioner Willie Phillips asked in January 2023, referring to the North Carolina attack. "Or [are these attacks] something that we can just expect more often?"

If people taking what could be called potshots at power infrastructure may not be that compelling, but there have been disruptions of domestic terrorists who testified they planned to trigger wider societal chaos by knocking down the power grid.

In Maryland, some Florida-based neo-Nazis planned to target the Baltimore power grid with sniper fire, according

Fencing and other physical barriers are one method of area denial for power grid equipment, although no one solution guarantees safety. Photo by Varandah, Dreamstime.

Bright security lighting is one of the more cost-effective means of deterring would-be attackers. Photo by Hramovnick, Dreamstime.

to an Associated Press report from February 6, 2023. One of the conspirators said the plan hinged on targeting the grid during cold weather during a time of peak electricity demand. The FBI emphasized their finding that the conspirators were not merely talking about such an attack, but actively taking steps toward carrying it out.

In my area, the Pacific Northwest, there have been 15 attacks on the power grid since June 2022, making the region a bit of a hotspot, according to Oregon Public Broadcasting.

When asked for a comment on power grid vulnerabilities, the Western Electricity Coordinating Council, the entity in charge of system reliability for the Western Interconnection, said it could not comment on any specifics, but provided a statement it put out jointly with NERC. The statement condemned the attacks and stated that the entities will continue to work with law enforcement before reviewing federal critical infrastructure protection (CIP) standards.

"NERC and industry take cyber and physical security extremely seriously. Among our Critical Infrastructure Protection (CIP) standards is a mandatory physical security standard (CIP-014) that requires utilities to have measures in place on their most critical assets to prevent cascading or uncontrolled outages on the bulk power system should a physical event take place and also to have methods in place to defend from such an attack," according to the joint NERC/WECC statement.

Guarding Against Vandals

Rick Ladroga, CEO of AI Electrical Power Industries and a power engineer for more than 30 years, took some time to answer my questions while traveling across the U.S. to investigate

the failure of a pair of transformers. He said physical security at substations and other vulnerable points on the grid has always been an issue, though perhaps not as much as today.

"I investigated a failure of an 840 MVA shell-form transformer 15-20 years ago in Missouri. The failure happened because an older retired man got himself liquored up and decided to do some shooting. His weapon was a deer rifle and his target was 161 kV transmission line insulators. He got one, and it flashed over several days later on a rainy day, causing millions of dollars in damages," Ladroga said.

For this act of drunken vandalism, the man was never charged with any crime despite the impact on the power grid. Those involved preferred that the incident not be shared with the general public at the time, Ladroga said.

Warning signs at a substation in Quebec, Canada, announce the dangers within in both French and English. Photo by Valmedia Creatives, Dreamstime.

Ladroga pointed out that cemeteries, freight rail and other properties are targeted by people whose only motivation is to break something.

"It's sick and twisted, but it's there," he said. "If these recent attacks on electrical assets were strategically planned and coordinated then the resulting damages and outages would be far greater and more severe in nature."

The high-profile substation attacks in Washington and in North Carolina happened to be on substations that did not rise to the level of criticality that they would be subject to the CIP-014 requirements, according to the statement. It went on to call the events "unrelated," but alike in the sense of showing that the physical vulnerabilities of the grid must be evaluated continuously.

CIP-014-1 requires utilities to identify T&D facilities and assets that, if damaged or made inoperable, could cause a cascading failure, widespread instability or uncontrolled separation within an interconnection. For facilities falling under this standard, the CIP requires recurring risk assessments, third-party reviews, security plans and resiliency countermeasures.

The standard was adopted about a year after PG&E's Metcalf substation was hit with long-range rifle fire in an April 2013 incident that caused about $15 million in damages.

While the FBI eventually determined that the attack was not terrorism, but likely an act by a disgruntled employee, the incident spurred state and federal actions.

The California Legislature also passed SB 699, directing the

A view of the Bayshore Freeway and the PG&E Metcalf substation just south of San Jose, California, where a shooting triggered a power outage and an industry-wide discussion in 2013. Photo by Andreistanescu, Dreamstime.

Regular inspections are another means of keeping critical T&D equipment functioning. Photo by Tom Wang, Dreamstime.

California Public Utilities Commission to develop new practices in support of power grid physical securities. Also in response, the large investor-owned utilities of California also asked for millions in rate case funding to support physical security. Solutions explored included extra security at substations, video surveillance, alarms and patrols, according to a 2018 white paper on physical security from the CPUC's Safety and Enforcement Division.

That white paper also states that even a well-coordinated attack on distribution facilities is not likely to result in a widespread system disruption or cascading outages because local grids have redundancies built in. Also, any individual distribution substation serves a relatively small service area.

"Depending on the design of the distribution system, redundancy can be built into system such that disruptions can be limited, and an affected distribution circuit can be served by an alternative substation," according to the CPUC paper.

Given that there are more than 55,000 substations, some 200,000 miles of transmission line and 6 million miles of distribution lines in the U.S. according to Department of Energy Office of Electricity statistics, it is not practical to, say, assign security guards to each, or even put every asset under surveillance. These grid assets don't just take up a lot of space. They are often built in isolated areas to boot, since people tend to want T&D equipment out of their way whenever practical.

Assessing the Threat

So the power grid presents would-be attackers with a target-rich environment. But how much of an issue is people shooting guns at power grid equipment?

Senior Vice President of Grid Security, Technical and Operations, with the American Public Power Association Adrienne Lotto said it is important enough for her group to pay careful attention to.

Drone photography of a large substation. Regular surveillance is one layer of protection that is open to asset managers. Photo by Vladyslav Horoshevych, Dreamstime.

"This is certainly an area of concern for APPA. Grid infrastructure and equipment are often located in rural areas and ballistic/firearm damage can occur for a variety of reasons—ranging from accidental/hunting discharges to vandalism/malfeasance," Lotto told T&D World. "That being said, it's important for people to know is that those who target grid infrastructure will be tracked down and prosecuted to the fullest extent of the law."

How damaging such attacks might be depends on the targeted assets, the weapons used, or even the conditions of the global economic system, Lotto said.

The ABB AssetShield is one of several products on the market that are sold as bullet resistant protection for transformers and other transmission and distribution equipment. Photo by ABB.

"Pole-top or substation transformers can get very expensive and increasingly hard to replace in the current supply chain environment," Lotto said.

Larry Fitzgerald, director, Security & Emergency Management for the TRC Companies said the threat profile is changing.

"Random events where distribution or even transmission grid equipment are vandalized by firearms have been going on for many years, often from a kid with a new firearm or a hunter on a slow day. What has changed in the last decade is that substations have started to be specifically targeted to cause outages on a local or regional basis. In the last 6 to 9 months the frequency of ballistic attacks against substations has increased substantially," Fitzgerald said.

The Idaho National Laboratory developed the Armored Transformer Barrier after the 2013 Metcalf substation attack, and it has since been licensed for production. The barrier is made of military grade steel that is "inexpensive, yet rugged," according to the laboratory. It was tested to defend critical infrastructure from explosives as well as high-powered firearms, as well as natural disasters like a Category 2 hurricane. The design is modular and can be shipped disassembled before being installed with common hand tools, utility cranes and forklifts. Photo by Idaho National Laboratory.

The attacks are often a mixture of "lone wolf" attackers, or small groups of terrorists, or individual thieves looking to strip valuable materials from equipment.

"There have been several recent publications and books by radically or ethnically motived groups and extremists to target various types of infrastructure using both explosives and ballistics weapons to cause damage and disruption often with the intent to undermine society and trust in various institutions such as the government and the reliability of the power grid," Fitzgerald said.

Fitzgerald said no one solution for physical security is unbeatable, whether they are area denial measures, shielded components, surveillance or patrols, but he added that a combined approach is the best for foiling all but the most determined attackers.

"There are many things that can be done to protect T&D facilities from ballistic attacks. Not one of them by themselves are foolproof, but layered and properly coordinated with other strategies, to build capability around the deter, detect, deny, delay, respond and recover security taxonomy would be the most effective," he said.

Specifically, he said, fences should be made higher and more critical components need to be located toward the center of the substation rather than along the fence line. This kind of layout, combined with randomized patrols and cameras that include thermal imaging would boost security from there.

"Electronic system such as outward facing ground radar, gun-shot detection and other systems can provide early warning of an unauthorized person approaching or using a firearm near the facility. Other technologies also can provide early detection and could be part of a layer security approach, along with ballistic hardening of critical areas," he said.

Stopping Bullets

Major manufacturers such as Siemens, Hitachi Energy and ABB have brought shielded transmission and distribution gear to market, and other vendors sell barriers and panels that meet the UL standards for protection against ballistic projectiles.

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The barriers come in four pieces: an A-frame, a pair of armor cassettes that slide in and an optional extension that makes the barrier taller for added protection. The design is modular and can be shipped disassembled before being installed with common hand tools, utility cranes and forklifts.

Swiss-Swedish automation multinational ABB introduced its own barricade system to shield transformers, the AssetShield ballistic protection system. According to the company, this equipment provides protection up to UL-752 level 10, which means it is resistant to .50 caliber rifle fire.

"AssetShield is an impact and fragmentation-protective system for substation equipment such as transformers, switchgear, circuit breakers, and capacitors. It reduces the kinetic energy of the bullets and reduces spalling after impact," according to a release by ABB.

"Absolute physical security for a substation is not practically achievable, but with AssetShield and other protective actions, it is possible to minimize the damage, prolong service and restore service more quickly when there is an attack." said Emily Heitman, Vice President and General Manager of Commercial Operations for Power Transformers in North America.

Right-Sizing the Response

Reasonable security measures are not judged by how well defended assets are, but on how robustly the grid is built as well as protected. If we build the power grid in a way that offers up fewer weak points, then these kinds of physical attacks could become less of a threat. Effective risk mitigation would address both the likelihood of these attacks and lower the consequences of one, should one happen.

As was said in the introduction to this piece, responding to terrorism is tricky because nobody should want to terrify people into a feeling of helplessness or despair. This is doing a terrorist's job for them. A response should be proportionate to the threat itself.

If FERC, in its investigation into the issue, was correct to say an ill-timed shooting could paralyze the power grid if demand was high enough and if the attackers knew precisely where the weak points were, then conceivably engineers could shore up those weak points without needing to assign security guards to every substation in the country.

Manny Cancel, CEO of The Electricity Information Sharing and Analysis Center (E-ISAC) and Senior Vice President with NERC, said incidents involving ballistic damage or gunfire are quite rare when compared with petty theft and vandalism.

"Those types of incidents, those with ballistic damage or gunfire, are the overwhelming minority of incidents. So fortunately, there aren't that many of them. There are a lot more of them are that are theft, people breaking in to steal copper wires, or defacement," Cancel said.

A relatively small number put the power grid into what is called an operating contingency, meaning damage that makes

equipment operate at less than maximum efficiency, or worse yet, an outage.

"That being said, they are significant, and we don't want people shooting at critical infrastructure. After these most recent incidents in the Seattle-Tacoma area and in North Carolina, we issued guidance on how utilities could harden their assets if they wanted to, and recommendations on what they could bring to bear, from fencing and barriers to cameras and patrols," Cancel said.

While conceding that the public does not know all the facts about every physical attack on the grid and who is perpetrating them, the latest major incidents seem to show that people damage power grid equipment for a variety of motivations.

"We don't know all the facts, but if you look at Seattle-Tacoma, they were thieves. The Baltimore incident, which the FBI got ahead of, they were ideologically motivated. The adversary here kind of runs the gamut," he said.

Cancel added that E-ISAC monitors some of the internet's darker corners where extremist groups are talking quite a bit about disrupting the power grid to achieve their goals, even though they may not necessarily know how to carry out such plans.

The existing standards, like NERC's CIPs, have done a good job protecting the interstate bulk power grid in North America, he said.

"These [standards] are less focused on distribution assets. That being said, many of the protections that are in place with the CIPs are used in other power stations. But there are so many substations that it is impractical to implement them all of them, so everyone has to evaluate their own needs and risks," he said, adding that any changes made to regulations should be about right-sizing them to the individual risk profile.

"Some facilities do invest in ballistic protections," he said. "It all depends on the risk profile of the specific asset. Let's say a station gets taken out. But the grid is very resilient. Maybe you design the grid differently so we can engineer it so it's more resilient."

Although the industry has taken security, cyber and physical, seriously for decades, sometimes a fresh look is needed, he said.

"Sharing information is critically important now. You should report stuff, and whether you want to report it to ISAC or not, you should report it to local law enforcement," he said.

Ladroga said the current regulations and industry best practices may need to be revised to account for more brazen attacks.

"Substations today need much better security," he said. "There are a number of measures that can be taken, including security walls and fences, cameras, and manning critical assets with security forces."

Cameras and lighting offer the lowest costs, with barriers and guards being more expensive. Still, Ladroga agreed that no one solution offers perfect protection.

"If an individual or group is determined to take out our grid, they can do it. That same fact holds for almost anything in our society. That is one of the main reasons why no one in the industry really ever talks about this issue," he said. "It's a similar story for the banking industry. They lose billions each year in electronic hacking incidents. They choose to keep the losses private to hopefully prevent others from trying." TDW

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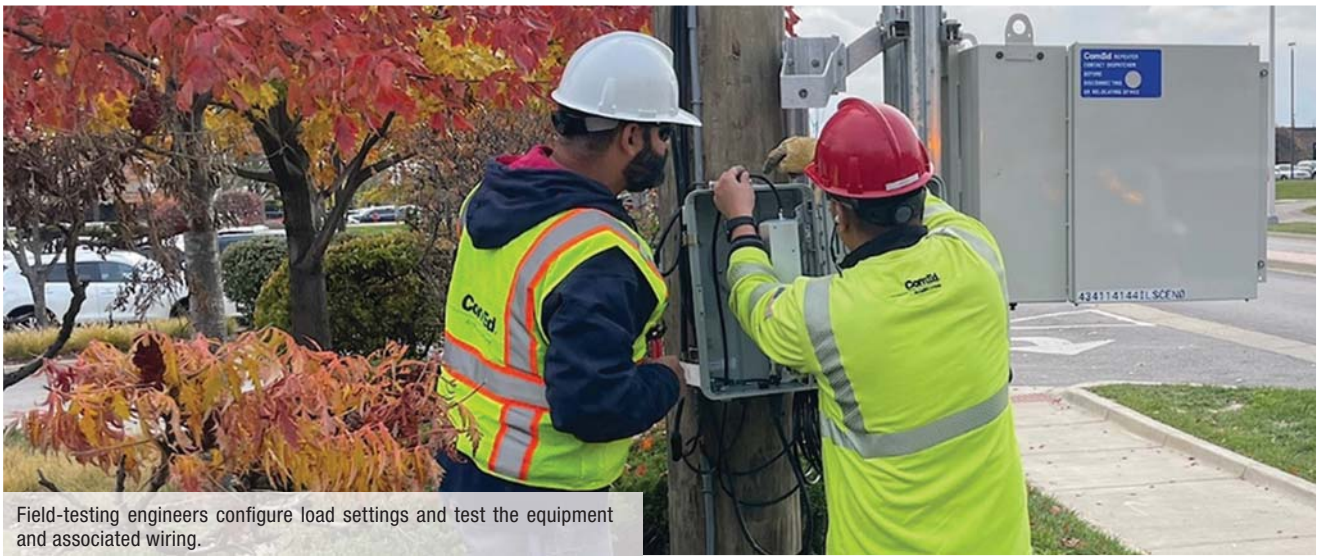


Field-testing engineers configure load settings and test the equipment and associated wiring.

Leverage Voltage Optimization for Energy Savings

Through voltage optimization, Commonwealth Edison is optimizing customer voltages and lowering power generation demand.

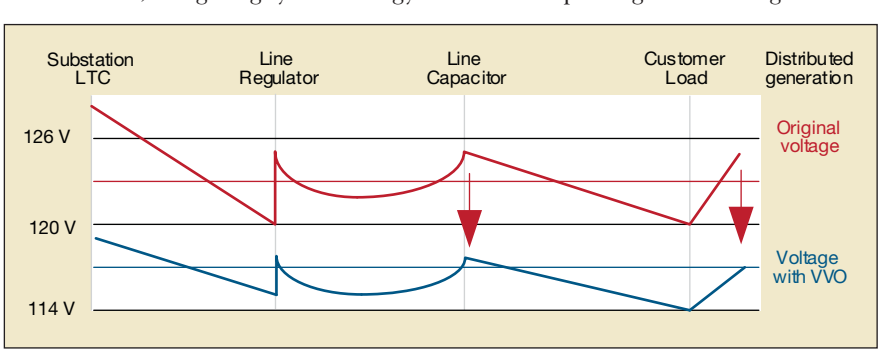
By **MARK PROCACCIO**, **JASON POZEN**, **SHEIKH RAJIB**, **WEN FAN**, and **ASHRAFUL HAQUE**; Commonwealth Edison

Through its large-scale voltage optimization program, Commonwealth Edison (ComEd), one of the largest electric utilities in the U.S., is connecting its 4 million northern Illinois customers to better electric service. The program is enabled by the Illinois Future Energy Jobs Act (FEJA) to enhance energy efficiency options and save on customer energy costs in ComEd's service territory, which encompasses 11,400 square miles and consists of more than 70,000 miles of power lines.

The primary goal of the program is to optimize customer service voltages and create equitable energy savings for customers across the service territory. In addition, VO is cutting the amount of fuel needed for power generation while lowering peak generation demand, mitigating system energy losses and improving system stability. ComEd customers do not need to change any of their energy usage behaviors to benefit from energy savings produced by the program.

VO includes a specific volt-var optimization (VVO) measure designed to minimize energy consumption and improve end-use efficiency by reducing the source voltage at the substation transformers. This is accomplished by dynamically adjusting the bandcenter of a transformer's load tap changer (LTC) to provide a lower voltage profile throughout the feeder.

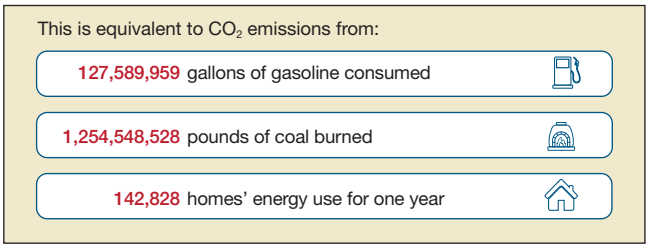
In conjunction with the LTC adjustments, each feeder distribution line is designed with VO-specific capacitor banks and voltage regulators to effectively tighten the voltage range without exceeding the lower voltage threshold limit.



Voltage profile of a feeder with and without VO.

These devices, along with end-of-line (EOL) AMI meters, provide data to the VO algorithm, which controls the capacitor banks, voltage regulators, and transformer LTC. Successful activation of VO on a distribution feeder results in an intelligent, real-time control of the voltage on the line to the end customers.

The program began with analysis of the entire ComEd distribution system that identified about 500 substations where VO deployment demonstrated a potential for



Equivalent of CO2 emissions avoided through ComEd's VO program.

cost beneficial impact for the customers. The program completed its first station activation in 2018 and is projected to complete initially identified stations by 2026. Once this first phase of the program is completed, the anticipated annual energy savings is projected to exceed 1,600 GWh.

Based on the average U.S. household energy use of about 12 MWh per year, the energy savings projected to be realized by ComEd customers through VO is equivalent to the annual power usage of about 142,828 households. This is equivalent to reducing around 1.13 metric tons of annual CO2 emissions from the environment.

The portion of the VO program deployed to date has met those expectations and has provided ComEd customers with more than 750,000 MWh of annual energy savings.

VO Operations

The operation of VO is achieved using a combination of intelligent devices on the distribution system controlled by a centralized software platform, which runs on a VVO algorithm. ComEd has a dedicated VO operations team that performs the initial commissioning of these new systems and devices and operates, maintains, and oversees the entire program.

The VO team works with different internal groups, such as capacity planning, project management, distribution automation, information technology, relay and protection, regional engineering, SCADA data maintenance, and distribution and substation field testing personnel to achieve successful activation and maintenance of a VO site.

The annual process begins with capacity planning selecting the top priority stations that will enable the team to meet the total energy savings commitment for the specified year. These are then provided to the project management team to manage budget, schedules, materials, and labor resources.

The relay and protection team provides the design details and settings for the station work and the capacity planning team provides design and settings for the distribution line feeder work. These design packages are then engineered, and drawings are sent out for the construction phase. Once the construction crews complete the work, the field-testing engineers configure load settings and test the equipment and associated wiring.

After field testing is completed, remote-end testing is performed and validated by both the SCADA data maintenance and VO operations team. The VO operations team then completes the process by modeling and linking all the components in the station to a central database, which enables VO to deliver energy savings to ComEd customers.

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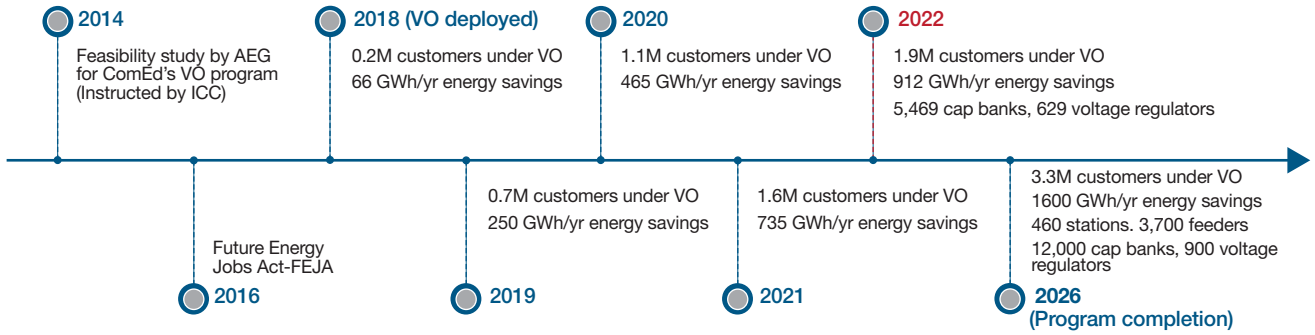

ComEd's VO program.

As the number of devices in the VO program grows, so will the cost savings provided by the new remote and automated conditional maintenance process.

The VO program continues to deliver on megawatt hour energy savings goals, a testimony to the innovation and continuous process improvements required to maintain its large-scale operation. When the program began in 2017, the VO management software system required manual input of individual fields to map a single point in the database.

Today, the team uses templates and automated processes built and customized internally to move hundreds of points into the program's database. These tools now enable the small VO team to manage significant workloads and deliver highly efficient energy to customers, enabling them to reduce energy consumption and costs of up to 2 percent annually. What's more, these automated tools and processes are showcased to other departments across the company in an ongoing effort to share and deploy best practices.

The VO team has also developed a remote capacitor bank maintenance process, which utilizes SCADA capabilities to create an auxiliary program that runs on top of the database user interface. This remote and automated process improves upon the traditional in-person annual service visits to each capacitor banks. The new preventive maintenance process identifies cap bank issues remotely, eliminating the initial need for a crew member to diagnose issues in the field and uses limited number of truck rolls if and when crews must be dispatched to resolve a problem.

This program allows the VO team to perform preventative maintenance more often and intelligently, leading to better year-round reliability and power quality. As the number of devices in the VO program grows, so will the cost savings provided by the new remote and automated conditional maintenance process. A similar maintenance process for VO voltage regulators is currently in development and is set to be deployed soon.

SCADA system rack is another innovation that allows the VO group to test and remotely troubleshoot SCADA communications and field controller settings in a lab environment. The test system simulates field equipment and SCADA network for a station. The unit has proven to be a valuable means of piloting and testing new equipment for field deployment.

Evaluation and Monitoring

Beyond the deployment of the technology in the field, it is essential to educate and build understanding among stakeholders about the benefits of VO. To that end, ComEd has worked with third party evaluators, regulators and other stakeholders to develop a systemwide conservation voltage reduction factor. The CVR factor is an index that is measured as the ratio of energy consumption reduction to the voltage reduction due to the deployment of VO.

A regression model has been developed to evaluate almost 200

feeders across the system with adequate VO enabled data. This has resulted in a load weighted average CVR factor throughout the system. Using this systemwide CVR factor, ComEd has developed algorithms to precisely estimate energy savings considering confounding factors like season, temperature, VO status, time of day, etc., in addition to reconstructing the data after necessary validation and correction.

After the VO operation is activated on a substation, the measurement and verification engineers collect necessary data and actively monitor the performance of that station to confirm energy savings and voltage reduction using developed algorithms. M&V engineers provide feedback when expected energy savings is not achieved, and actions needs to be taken to enhance VO operation.

To fully leverage the value of VO system monitoring, ComEd is using a PI asset framework to continually monitor VO devices, perform advanced analytics, and process real-time notifications on system behaviors. Communication signals sent by the VO control platform and field measurements from VO devices are brought into the AF environment, where further analyses are performed and historized.

Based on these analytics, automated email notifications are generated and distributed to appropriate workgroups to raise situational awareness and promote rapid actions to ensure that VO systems are healthy and operating effectively.

Table 1. Advanced PI AF analytics developed by ComEd team for CVR monitoring.

Developed Advanced Analytics
Substation health score
CVR status detection
CVR ON/OFF cycle duration
Average voltage reduction
Substation transformer LTC status
Substation transformer no-load tap Status
Capacitor bank neutral current
Phase imbalance

The VO team also uses the PI-AF software to construct informative displays that provide real-time data feedback from several VO stations. The information is available to other ComEd departments, such as the Distribution Operations Command Center, as an easy-to-use visual monitoring dashboard.

In addition to using the PI-AF to perform advanced analyses and monitor behind-the-scenes system behaviors, the VO team is also using an alarm management and monitoring application. This application provides a front-and-center display which allows for incoming alarms and events to be filtered based on user

Examples of the views created by the VO group include capacitor bank alarms/events, communication issues with LTCs and line devices.

defined criteria. Displays with specific criteria sets can be saved as views; examples of the views created by the VO group include capacitor bank alarms/events, communication issues with LTCs and line devices, and possible control failures.

ComEd's VO program is one part of its strategy to deploy grid investments that help uplift communities and to meet the needs of customers by enabling them to reduce energy consumption and costs. ComEd is committed to the program through investment, continuous improvement and innovation, and industry standards.

As the program evolves, the team continues to enhance both the activation and maintenance processes. The VO team is

continually investigating ways to improve the capacitor bank and voltage regulator maintenance process to maximize sustainability through continuous monitoring of the extensive and growing system using automation.

The VO team continuously looks to automate manual processes, such as device creation and equipment functional testing, to reduce or eliminate labor-intensive tasks. ComEd invests in research and works with manufacturers on devices to add to the capabilities of the VO program. One such device is a dynamic VAR controller installed on the secondary line side providing data, control, and VAR support.

ComEd is continuously collaborating with the utility industry by publishing those successes and the standards they are built upon at various leading international conferences. ComEd is committed to delivering continued results for its customers through expansion and improvement in VO. TDW

Acknowledgments

Other contributors to this article include: Cody Walsh, a member of the Voltage Optimization Operations team since June 2022; Luke Workman who has been supporting the Voltage Optimization group at ComEd for the past four years as a contractor and as a full time ComEd employee; Brooks Glisson, Sr., senior manager of Reliability Programs where he manages the Voltage Optimization department to increase efficiency and intelligence across ComEd's distribution system; and Paul Pabst, Sr., the senior manager of Emerging Technology within ComEd's Smart Grid Department.

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The team is conducting a four-year study to restore approximately 20 acres of California prairie under and around the solar panels. Photos by SMUD and EPRI.

California Prairie Restoration Among the Solar Arrays

The site of a decommissioned nuclear power plant and current solar power project could teach a utility how to sustainably manage land, water, wildlife and vegetation.

By **JESSICA FOX**, EPRI, and **KATHLEEN AVE**, SMUD

A new restorative energy collaborative project is underway in California. The project combines renewable energy, prairie land conservation, scientific research, and benefits to the local community — and bees and butterflies are at the heart of it.

Many ecosystems completely depend on pollinators. Fundamentally, we need bees to produce our food; plants are 75% dependent on pollinators. Industrial farmers often cultivate honeybees to pollinate their crops. Globally, more than 30,000 species of pollinators create seeds that contribute to the food chain for many animals. They help create habitats, contribute to oxygen production, and protect the environment, giving the earth the capacity to withstand and recover from storms, wildfires, and floods and rebuild itself after disaster strikes.

This pollinator project, known as the SMUD Rancho Seco Restorative Energy Project and led by the Sacramento Municipal Utility District (SMUD) and EPRI, aims to restore prairie land and pollinator habitat at SMUD's 2,000-acre Rancho Seco site in Sacramento County, Calif. The team is conducting a four-year study to restore approximately 20 acres of California prairie under photovoltaic solar panels, in surrounding hedgerows and in pollinator gardens in and around the site's recreation area. The research team also includes the University of California, Davis, the Xerces Society for Invertebrate Conservation, D.E. Shaw Renewable Investments, and NovaSource Power.

SMUD's 160-MW Rancho Seco Solar II project occupies part of the site of a decommissioned nuclear power plant that was retired more than 30 years ago. The Rancho Seco solar power facility repurposed the surrounding land and became operational in February 2021. SMUD purchases the solar power generated from the facility as a source of renewable electricity for its customers under a long-term contract.

The solar installation at the core of this project is part of SMUD's pathway to achieve zero carbon emissions from its power supply by 2030. On the road toward a clean energy future, SMUD will expand renewable energy generation, such as wind, hydro and solar, support residential solar and battery storage technologies, promote electrification of transportation and buildings,

and continue to strengthen partnerships that accelerate zero-carbon technologies and innovation that benefit the region.

While solar power is important to the clean energy transition and reduction of emissions, ground-mounted solar can change landscapes and their underlying ecosystem functions. This project explores opportunities to simultaneously produce renewable power and promote restoration of ecosystem services, resulting in greater capacity for carbon sequestration, larger habitat for pollinators, and other benefits. The research aligns with California's priority to advance biodiversity conservation on working land and conserve 30% of land by 2030, known as 30x30 California, as well as the similar United Nations 30x30 biodiversity commitment.

The site uses sheep grazing as the primary vegetation management approach around the panels.

With the land now repurposed for solar energy, public recreation, an endangered species conservation bank, and a sanctuary for rescued wildlife, SMUD and EPRI are working to restore the prairie biome that once served as habitat for California's biodiverse pollinator species, including the migratory monarch butterfly. This study is currently focusing on approximately 20 acres and collecting metrics that measure soil carbon, energy production, pollinator diversity and abundance, native plant establishment, and cost.

California's Great Central Valley was once abundant with wildflower species, which supported pollinators, but much of this habitat has been lost. Native bees, honeybees, and butterflies have all experienced population declines over the last decade due in part to habitat loss.

When selecting species for pollinator habitat, the use of native flowers is preferable over non-native and ornamental flower species. Native plants are adapted to local growing conditions, including soil type, temperature, and moisture levels, meaning these species are more likely to establish and survive. Even flower color and shape influence visitation by pollinators. Research has

SMUD's 160-MW Rancho Seco Solar II project occupies part of the site of a decommissioned nuclear power plant that was retired more than 30 years ago. Photos by SMUD and EPRI.

found bees prefer yellow, blue, and pink flowers, while butterflies often visit yellow, pink and purple flowers.

The shape of the flower determines which pollinators can access pollen and nectar based on the pollinator's physical characteristics. The plant species selected for the study area include a variety of plants native to the ecoregion, including those that support "specialized bees," which are dependent on specific plant-insect relationships. Four very specific seed mixes were custom designed by the project team for this project to test various research elements, including changes to energy generation of solar panels, pollinator assemblages, and soil carbon.

Xerces biologists have experience creating pollinator habitat in California's Central Valley and are contributing to this project by leading the design of hedgerows and other plantings around Rancho Seco. These plantings will benefit a variety of pollinators, including declining species like the monarch butterfly.

The pollinator habitat's expected outcomes include the establishment of native plant species promoting pollinator habitat, soil carbon monitoring, energy production impacts, public education and workforce training and measured scientific results for peer-reviewed publication.

Additionally, the site uses sheep grazing as the primary vegetation management approach around the panels. This is known as agrivoltaics, a form of solar ecosystem stewardship that combines solar energy generation with crops or animal grazing to maintain the natural environment and agricultural benefit on the site.

Dual use projects that co-locate the agrivoltaic practice of on-site sheep grazing could be models for future net-zero utility-scale projects. With the growing deployment of ground-mounted solar, agrivoltaics can provide agricultural enterprises with diversified revenue sources and ecological benefits, while reducing land use competition between farming and solar energy production.

This project will also serve as a testbed for scientific research while training the next generation of sustainability scientists through research and mentoring. Students from the University of California Davis Wild Energy Center will engage in projects across SMUD's Rancho Seco solar treatment areas, exploring:

- Native plant mix selection and re-establishment, including across the solar facility areas and hedgerows.

The pollinator habitat's expected outcomes include the establishment of native plant species promoting pollinator habitat, soil carbon monitoring, energy production impacts, public education and workforce training and measured scientific results for peer-reviewed publication.

- Plant community and pollinator habitat assessment, with biodiversity and habitat suitability analyses.
- The characterization of soil properties, including soil carbon sequestration.
- Habitat and restoration options for California tiger salamander that nests under the solar panels.
- Projects emphasizing co-development and engagement with tribes and co-locating energy and socio-ecological benefits, including environmental justice.

What's more, the Rancho Seco Recreation Area receives approximately 100,000 visitors per year who birdwatch, boat, swim, camp, fish, and hike. The project team is creating multiple educational opportunities in the pollinator gardens to benefit future visitors.

This Rancho Seco project highlights a novel collaboration at the intersection of communities, biodiversity and climate-friendly energy. Over the course of this collaboration, the team, with EPRI at the helm, will balance the many aspects of the project from the interests of the solar project owner and operator, landowner, regional tribes, state and federal wildlife agencies, shepherds, neighboring vineyard and local species. TDW

JESSICA FOX (*JFox@epri.com*) is a senior technical executive at EPRI, an independent, non-profit energy R&D organization. In 2018, she launched the EPRI Power-in-Pollinators Initiative, which is now the largest effort in North America for energy companies to collaborate on pollinator conservation research and projects. From 2011-2016, Fox led EPRI's Energy Sustainability Interest Group to become the largest collaborative forum in the industry to advance issues related to sustainable electricity. She has a bachelor of Science from University of California at Davis, and a Master of Science from Stanford University.

KATHLEEN AVE is senior climate & ecosystem strategist in the Sacramento Municipal Utility District's Customer and Grid Strategy department and the Emeritus Chair of the Electric Power Research Institute's Power in Pollinators initiative. Her current work is focused on biodiversity and habitat conservation, climate readiness, and agrivoltaics, including the collaborative Restorative Energy project. A past chair of the Capital Region Climate Readiness Collaborative, she has helped fund and develop renewable energy projects ranging from solar to co-digestion with wastewater treatment.

BY **STUART NACHMIAS**, CON EDISON TRANSMISSION

HVDC is a technology choice when moving electricity longer distances from offshore wind generation to land. Photo by Ian Dyball, Dreamstime.

Evolution or Revolution?

The transmission lines that will carry clean energy is so far lagging behind the development of installed clean energy capacity.

Reaching current U.S. decarbonization goals will require a doubling or tripling of the current transmission capacity to deliver that power to where it's needed. Today, there are already over 1.3 terawatts of proposed wind, solar and battery energy storage storage projects in interconnection queues in the process of connecting to the grid. Whether due to a lack of consensus in regional transmission planning, challenges with permitting and/or cost recovery, the development of needed transmission capacity has lagged.

In addition, there is often a lack of understanding that a massive nationwide transmission expansion is required to cost-effectively transform the U.S. power system on a timeframe consistent with those goals. Coordination and cooperation could certainly be improved within and among regions across the country to better meet our national policy goals.

Integrating offshore wind into a nationally connected grid is also necessary to meet U.S. goals, particularly for the Northeast and Mid-Atlantic coastal regions where there are significant offshore wind resources and insufficient land available for wind development. East Coast states have already set goals to procure more than 30 GW of offshore wind, with state-specific decarbonization studies suggesting well over 100 GW of East Coast wind generation is needed by 2050. Moreover, with additional transmission capability, the generating potential of Canada's wind and hydroelectric resources could provide dispatchable clean resources and grid flexibility for the Northeast, upper Midwest, and Pacific Northwest.

New York is fortunate to have access to plentiful renewable energy resources. In fact, Con Edison Transmission plans to invest over $1 billion over the next decade to develop electricity transmission to bring clean renewable energy from where it is produced to where it is needed to serve customers. Advocating a "transmission first" approach, Con Edison Transmission supports building transmission capacity before renewables are ready to simplify and streamline interconnection processes, recognizing that transmission development and siting generally takes longer than comparable processes for generation. Moreover, pre-building transmission including by the local utility can send better signals to prospective resources on suitable places to connect on the system.

Clean electricity generation is only possible with grid enhancement to enable reliable and resilient delivery systems. If we want to share our high-quality resources with neighboring regions, regional and interregional systems, including consideration of a macro grid concept, will work best. The benefits of expanded regional and interregional transmission are innumerable and vital to meet customers' energy needs.

Onshore renewables from the Midwest may help the more densely populated coasts, but offshore wind along the coasts will also help the Midwest. In short, a more interconnected grid

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helps all customers, and as such, all customers should contribute to costs fairly. Enhanced power delivery systems provide economic development, resource and load diversity, improved system performance, extreme weather resilience, and strengthen the grid to operational failures. Bi-directional power flow within this upgraded system enables all consumers to benefit from the time-zone diversity, allowing available resources to be used optimally, and in the event of extreme weather, providing access to longer-distanced generation sources.

Numerous studies indicate that the wide-scale diversity of renewable resources, storage, demand-side management and other balancing resources significantly improve the quality of electricity supply. Several studies have shown that regional and interregional transmission provides many benefits. High voltage direct current (HVDC) technology may provide greater benefits when longer distances are needed because HVDC transmission has lower costs when transmitting electricity over hundreds of miles. Transmission across large regions, or across multiple regions can take advantage of HVDC for important economic and reliability benefits at a relatively low cost. HVDC is also a technology choice when moving electricity longer distances from offshore wind generation to land.

Onshore renewables from the Midwest may help the more densely populated coasts, but offshore wind along the coasts will also help the Midwest. Photo by Alexey Stiop, Dreamstime.

Pre-building transmission including by the local utility can send better signals to prospective resources on suitable places to connect on the system. Photo by Billy Blume, Dreamstime.

The overall objective of a more nationally connected grid is worthy of thoughtful deliberation. A strategic, targeted investment in new regional and interregional transmission, including consideration of a macro grid, will enable a more cost-effective, faster, and ultimately more successful transition to clean energy resources. And a well-designed macro grid built in several stages could allow balanced, reliable operations to be maintained throughout the construction process.

Numerous efforts are currently underway at the federal, regional, state, and local levels to improve coordination that could eventually lead to this undertaking. Despite that, connecting utility-scale renewable resources, distributed generation, storage, flexible demand management, and energy efficiency is not a task easily accomplished. We will need more work on how to design and build large-scale transmission within regions and to interconnect regions and resources. It will take time and require agreement and support from many stakeholders across large geographic areas. Yet it can be done. Together, step-by-step, with leadership from the utility sector and key regulatory bodies, we can create a strong foundation for the 21st century electricity infrastructure. TDW

STUART NACHMIAS is president and chief executive officer of Con Edison Transmission, the company's wholesale transmission business. Con Edison Transmission develops projects in the MISO, PJM, New York and New England regions. He also serves as Chair of the Board of Managers for New York Transco, a joint-venture transmission company comprised of Con Edison and New York State's other investor-owned utilities. Nachmias holds an M.B.A. degree in finance from Baruch College, and earned a bachelor's degree in both economics and psychology from Binghamton University. Nachmias is a board member of the Tenement Museum, which seeks to educate visitors about immigration experiences across cultures and ethnicities, and the Queens County Farm Museum, which has New York City's largest remaining tract of undisturbed farmland dating back to 1697.

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Bird Diverters at Bagnell Dam

OUR APRIL FEATURED LINEWORKER

Kyle Kusser

Basin Electric Power Cooperative

- Born in Pierre, South Dakota, and grew up in Highmore, South Dakota.
- Married to his wife, Madee and has three children: Logan, 12; Taylor, 9; and Brody, 6.
- Enjoys coaching youth activities and spending time with his family. He also likes hunting, fishing, boating and going to the gym.
- Is the first lineman in his family.
- In recent years, he says storms have been the biggest challenges. With his background in construction, however, he gets excited when he gets the call to go on storm work.

Early Years

I got into the industry sort of by chance. I went to Mitchell Technical Institute to be an electrician and graduated with my associate's degree. Then I enrolled in the power line program for my third year. Having always loved heights, I fit in the line trade perfectly.

Day in the Life

I got my start in the contractor world building transmission lines in the Black Hills of South Dakota. I spent five years with two different contractors building line in a four-state area. It wasn't until I met my wife and had our first child that I realized it was time to slow down and be home more. That's when I started working as a maintenance lineman with Basin Electric in Gettysburg, South Dakota. As the lead lineman at this outpost, most of our days consist of patrols and maintenance along with routine upgrades to our structures. We also do hot stick and barehand work on 345 kV.

Lead Lineman Kyle Kusser said he was made to work in the line trade and enjoys working out in the field.

On the Job

Right now, we are catching up on maintenance. We spent last summer picking up what a few tornadoes tore down. Going forward, we will be installing storm structures on one of our 230 kV lines and performing structural upgrades on lattice towers. We will also be knocking out some routine hot stick jobs like tightening vibration dampers and replacing spacers on our 500 kV construction. There are always shakedowns and climbing inspections to do as well.

Tools and Technology

I will always say that a lineman's best tool is a rope and his knowledge of how to use it. As far as new technology, I love what the electric tool industry is doing for tradesmen these days. It seems like every other week they come out with something new that will allow us to maybe age a little slower.

Safety Lesson

I've never lost a coworker, but I have had a few friends who were involved in incidents. My friend went down in a chopper and was the only one who survived, and I had another friend who lost his life at the end of a helicopter longline. I've witnessed a journeyman get locked onto a line that had induction on it. One time, I received a jolt of induction so hard it felt like taking a steel toe to the belly button. I was lucky, but I am not invincible. None of us are. Since then, I have taken induction more seriously.

Memorable Storm

I'll never forget the 2010 ice storm in Bowman, North Dakota. Everything was down in a giant swath across the state. At the time, I was working for Brink Constructors, and we were there for five weeks. In that time, crews on scene replaced more than 4,000 poles and miles upon miles of wire from Bowman to Bismarck, North Dakota.

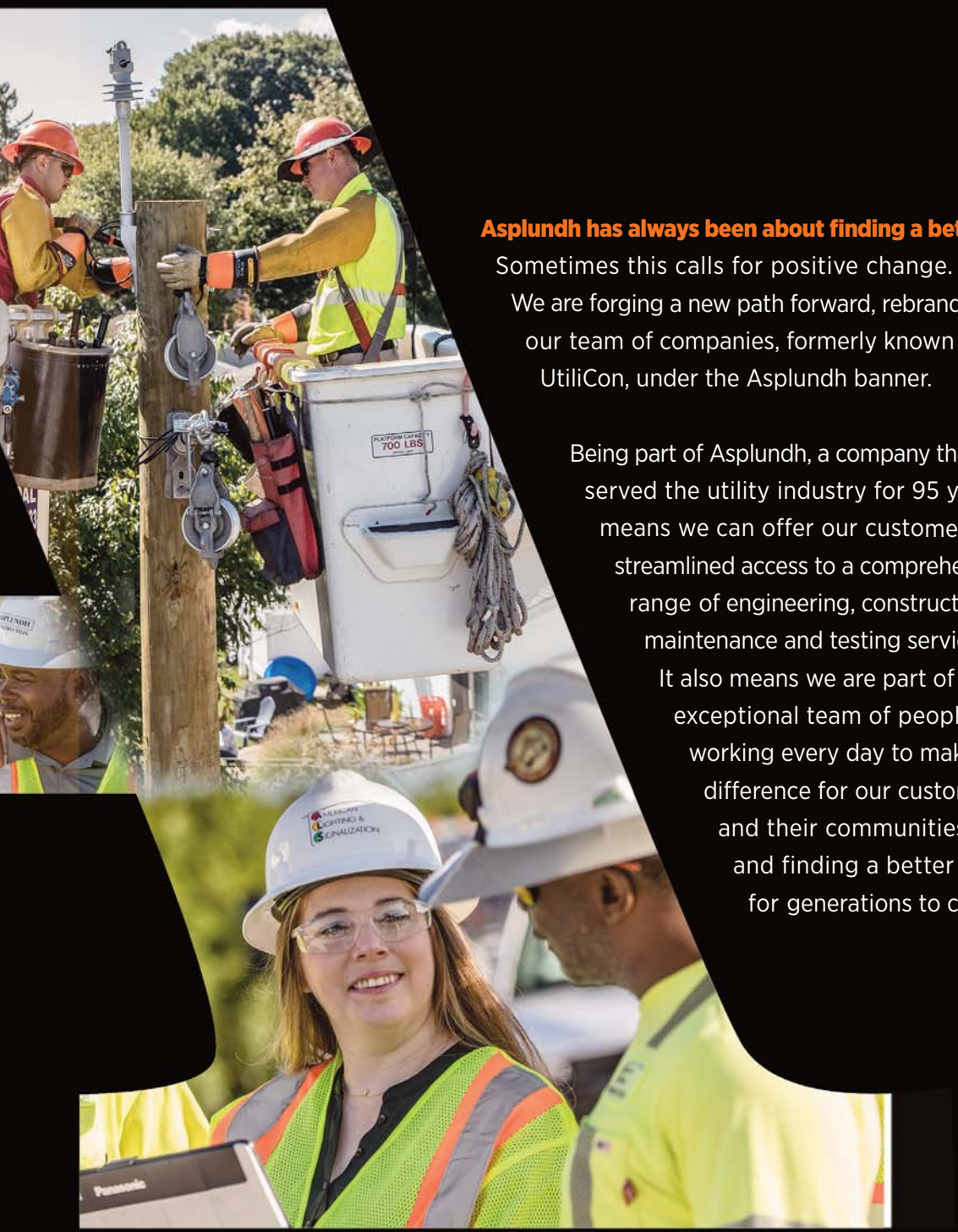
That was the coldest I have ever been in my life. It had snowed so much that everything that was down was buried deep into the snow. Because I worked for a transmission line contractor that builds line across the Black Hills and other rugged terrain, we were more than equipped for the situation and handled it very well. We got treated like rock stars on that job, and it felt great.

Plans for the Future

When I was in school, I knew that the transmission industry was my niche. I believe I was made for it. That's the road I chose, and I never detoured. I love all the tall towers, high tensions, big trucks, and heavy tools.

I'm not sure what the future holds for me. As my kids grow up, I've got no problem staying right where I am. I may have interest in more of a supervisory role someday, but I feel like I have plenty more to contribute to the industry right now. 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 linemen for their dedication to the line trade, Milwaukee Tool sends each profiled lineman a tool package.



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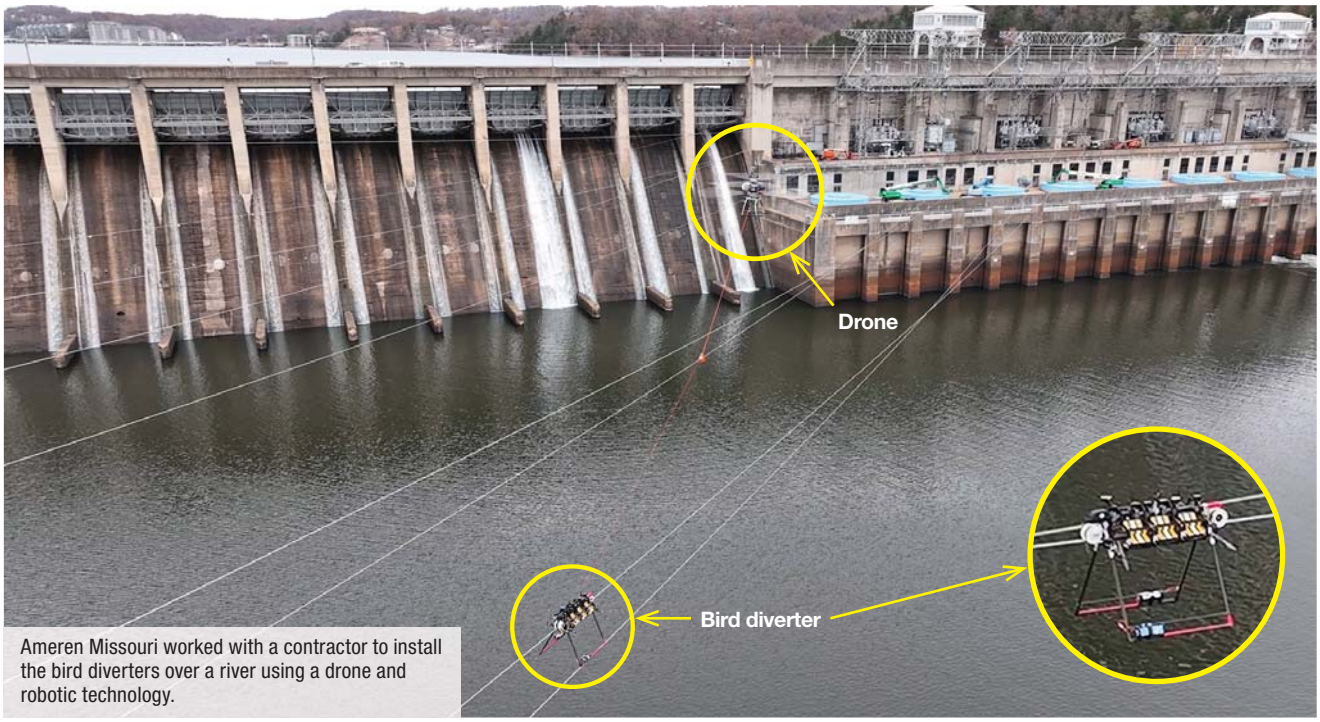

Ameren Missouri worked with a contractor to install the bird diverters over a river using a drone and robotic technology.

Drone-Installed Diverters Prevent Bird-Line Collisions

Ameren Missouri partnered with a contractor to install bird diverters via drone on distribution and high-voltage transmission lines above a river.

By **AMY FISCHBACH**, Field Editor

Bald eagles are flocking to the Lake of the Ozarks region in Missouri. To protect the nation's symbol, Ameren Missouri recently installed high-visibility flight diverters on distribution and high-voltage transmission lines over Bagnell Dam before the eagles began to nest in the area for the winter. Prior to the installation, Ameren Missouri conducted an environmental permitting review, which included avian protection.

For many years, the utility has partnered with the U.S. Fish and Wildlife to assess possible hazards and reduce their impact on the avian population. For example, linemen have installed covers prohibiting not only eagles, but also raptors, hawks, owls, and other large birds from striking multiple energized phases at the same time.

Through its avian protection program, Ameren is not only protecting wildlife, but also the integrity of the distribution system, according to Kurt Rakers, supervising engineer with Ameren Missouri.

"It helps our energy delivery system and maintains resiliency for our customers," he said. "At the same time, if there is any accidental collisions or phase-to-phase contact, we would be putting our customers out of power. Ameren also strives to be a good steward of the environment and maintain a conscious effort for the birds as well."

Randy Hunt, supervising engineer at Ameren Missouri, said the company has been intentional about taking proactive measures to protect birds throughout its region. "Our avian protection programs have resulted in reduced avian-related incidents within our service territory and have become a model for other utilities," he said.

Installing Diverters

Line crews recently installed new transmission lines near Osage Energy Center at the Lake of the Ozarks. This was a prime opportunity to use avian protection, in particular flight diverters, on those new transmission and adjacent distribution lines.

Typically, linemen would install the bird diverters using hot sticks. Because the power lines were above a river, Ameren considered alternative approaches. Drones provided the safest and most reliable installation method compared to using a helicopter. In collaboration with Power Line Sentry, the manufacturer of the Hawk Eye Bird Flight Diverters and Fulcrum Air, flight diverters were installed with the LineFly robot for the first time on an Ameren system.

"The drone and robot are safely controlled by the Fulcrum Air pilots, which is the quickest, safest, and most effective method for bird diverter installation at this time," Rakers said.

During the installation, the team maintained communication with the pilot and an onlooker to ensure safety in the power line environment.

"Once the robot is in position, it drives down the length of the wire, precisely installing each of the Hawk Eye diverters," Rakers said. "They are designed to be installed onto the wire by the robot in a fashion that allows the diverter to cradle the conductor without pinching, compressing or causing damage to the wire."

As Fulcrum Air installed the bird diverters, a bald eagle sat up in a tree and watched the action unfold.

"It was really incredible," Rakers said. "He was very curious as to what we were doing as we installed the diverters over the 35 kV lines."

A bald eagle flies over Bagnell Dam. Courtesy: Rick Wilhoit and Ameren Missouri

Preventing Collisions

Avian collisions are most common in low-light times like dawn and dusk due to the birds' feeding, roosting, and nesting behaviors. The birds are most active during these time periods as they search for spots to perch to look for food.

The risk of collisions may also be increased in low-visibility weather conditions.

"Because the birds' risk of collision increases in low light, reflective and glow-in-the-dark materials were vital," Rakers said. "We used Hawk Eye Bird Flight Diverters that glow-in-the-dark,

Protecting Avian Populations

The latest project to install bird diverters on the power lines at the Osage Energy Center is part of Ameren's company-wide program to protect avian populations at transmission and distribution facilities. Ameren developed the program in partnership with the U.S. Fish and Wildlife Service and is committed to the following:

- Retrofit facilities at highest risk of avian incidents or wherever incidents occur.
- Develop avian-safe standards for all new T&D construction projects.
- Train Ameren Missouri line, engineering, and support co-workers on avian-safe practices.
- Report any incidents to the USFWS.
- Invest in avian health partnerships, such as support of bird rehabilitation centers like the World Bird Sanctuary and Illinois Raptor Center.

are reflective, and have 360-degree visibility. "These high-visibility line markers prevent high speed collisions by providing time and distance for the bird to divert from that power line."

This contrast can be achieved through surface area, texture, brightness, reflection and glow, he adds.

"As these birds are utilizing the river, they are not paying attention to their path of travel," Rakers said. "They have feeding on their minds at that point in time, and these catch their eye."

As part of the project, Fulcrum Air installed a total of 300 highly reflective markers on the distribution and transmission lines.

During the installation, flight diverters were placed every 30 ft on the power lines to meet the recommendations of the Avian Power Line Interaction Committee. For locations with a history of bird collisions, the diverters are placed in 15 ft increments.

At Ameren, line crews are involved with avian protection on an everyday basis. If the crews cannot meet these spacing requirements, they are required to place polyethylene covers over the live-line parts of the conductors and devices. The hotline parts are covered to prevent phase-to-phase contact.

"The materials that Ameren uses to cover the conductors and devices are evolving on an everyday basis to gain extra life," Rakers said. "Going forward we plan to maintain our spacing requirements and adhere to avian specifications, however, if there is room for improvement, Ameren will strive to achieve it." TDW

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

Editor's Note: To learn more about the project, listen to Line Life podcast at *www.tdworld.com/podcasts.*

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Parting Shot

Photo courtesy of **ENTERGY CORPORATION**.

Lineworkers make reliability improvements to a distribution line as the sun begins to set in Jefferson Parish, Louisiana.

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ABB's high-inertia solution combines a mid-size synchronous condenser with a flywheel. Graphic by ABB.

Helping the UK Power Grid Spin Back its System Inertia

The way to a more stable UK grid may lie with a new application of an older technology: synchronous condensers.

By **GUY NICHOLSON**, Statkraft

National Grid Electricity System Operator (NGESO), the operator of the Great Britain electricity system is focused diligently on a target — to be able to operate a zero-carbon electricity grid by 2025. This is sparking a transformation of the British electricity system that is being watched with interest by system operators and manufacturers around the world.

As more renewable energy sources are connected to the electricity system and renewable energy generation increases, new ways to maintain system stability are required. This vital transition from large fossil-fuel plants to renewable energy generation presents a need for innovative solutions that can maintain system stability, increase the amount of renewable energy delivered via the grid network, and reduce costs for consumers.

Inertia is the energy stored in a large rotating mass like a generator or some industrial motors. Historically, the power system relied on the inertia inherent in large, centralized generation plants to keep it stable. Inertia acts rather like a car's shock absorbers that smooths the shock over bumps in the road.

Inertia provides a response that is temporary and is typically available for only a few seconds. That allows the power grid to ride though short duration faults. This keeps system frequency within controlled limits of around 50 Hz. In an intact, stable system, the frequency of electricity across the power system remains the same and can react to any loss of load or generation due and is robust against disturbances.

Renewable energy generation reduces the impacts of climate change and is essential to NGESO's goal of operating a zero-carbon electricity grid by 2025. However, the replacement of large fossil-fueled generation with wind and solar removes much needed inertia that has to be dealt with. In addition to the increasing connection of renewable energy, utilities are also experiencing a growing trend for the large numbers of electric motors in industry and commerce that operate with variable speed drives. While this is an important contribution to energy efficiency, it also results in a further loss of system inertia. These factors have contributed to NGESO reporting an historic and anticipated fall in system inertia.

In its operability strategy report published in December 2022, National Grid said that its current policy was to ensure that system inertia was always above 140 GJ. However, it notes that, by 2025, its ambition is to maintain a minimum system inertia of 96 GJ.

ABB's high-inertia synchronous condenser. Photo by ABB.

Providing Stability Services

In January 2020, NGESO announced the results for its first Stability Pathfinder approach to managing the stability of the British power grid. Contracts were agreed with five parties (including Statkraft), worth around $400 million over a six-year period, to either build new or modify existing assets to provide the vital stability services. The key service to be provided by Phase 1 is inertia, but without delivering any extra electricity on to the grid. This will, therefore, allow more renewable generation to operate and ensure system stability at lower costs.

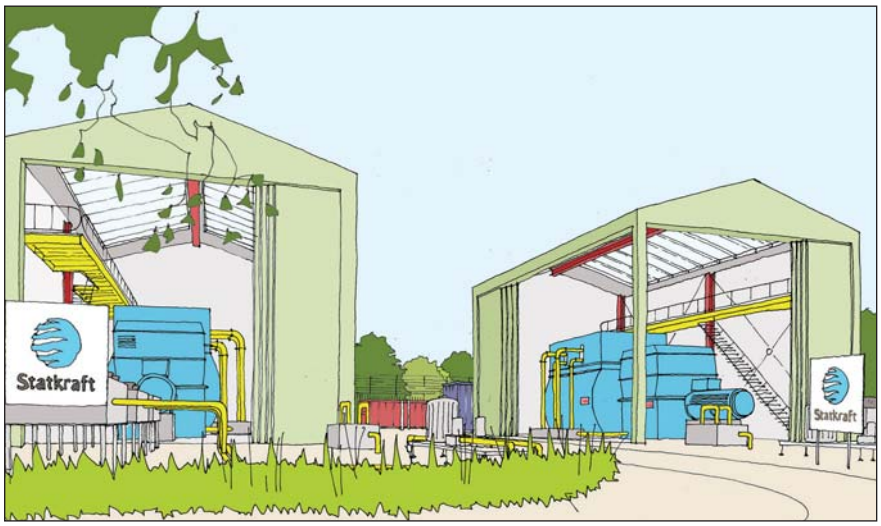
In total, the contracts for Phase 1 are procuring 12.5 GJ of inertia. That is equivalent to the inertia provided by about five coal-fired power stations. It was estimated at the time that this approach would save consumers up to $158 million over the six-year period. However, with the surge of gas prices in 2022, it is likely that it will result in much more than this.

As electricity needs are increasingly for energy generated from renewable sources, there will be longer periods where there will be no need for fossil fuel generation and, therefore, additional stability services will be required by projects such as the Lister Drive Greener Grid Park. On April 20, 2020, NGESO had to request generation from 17 gas-fired power plants simply for their stability services, increasing carbon emissions and consumer costs.

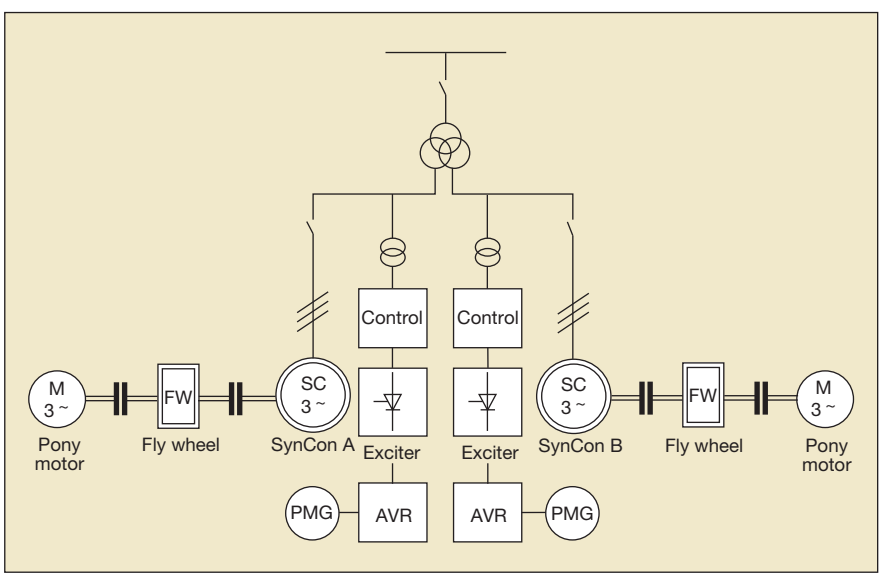
Greener Grid Parks

Statkraft is contributing to the Stability Pathfinder initiative through its Greener Grid Parks. One of these is now operational in Moray, Scotland, while the other site that houses two of ABB's high-inertia synchronous condensers is Lister Drive, recently commissioned in Liverpool, England. Statkraft is progressing several more potential projects across England, Scotland and Wales.

The Lister Drive Greener Grid Park project will provide services including inertia, voltage control and short circuit current, which provide system strength. The site was selected due to its location near to an existing substation that enables



An artists' impression of the Lister Drive Green Grid Park in Liverpool. Graphic by Statkraft.



Single line diagram showing the connection of the synchronous condensers and flywheels. Graphic by Jason Hill, Statkraft.

the two condensers to connect to the system at the transmission voltage (in this case, 275kV).

Synchronous Condensers

A synchronous condenser is a synchronous machine that is similar in design to a large motor or generator. However, in this context, it is not a motor, as it does not drive anything. Equally, it is not a generator as it does not have a prime mover. However, the condenser draws a small amount of power from the transmission system to supply its inherent losses used keep the condenser rotating.

Fifty years or so ago, synchronous condensers were common in the power industry but in recent years they have become much less common. This is because their former prime function, dynamic reactive power compensation, can be handled by modern power electronics equipment. However, the system stabilization issues discussed are driving the return to rotating devices with physical inertia that replicates the operation of large generating plant.

Synchronous condensers contribute to stable power systems in three main ways:

Inertia support for frequency stability — There is an increasing level of asynchronous resource being connected to the electricity system. These include interconnectors, wind, solar, tidal and battery energy storage systems (BESS). Condensers have a large rotating mass that provides inertia. They can help by damping frequency deviations, which gives both automatic frequency response plant and manual system operators more time to respond to frequency changes.

Fault level contribution — In the event of a transmission system fault, asynchronous technologies provide less fault current than synchronous technologies. This is because asynchronous plant with power electronics controls its fault current capability to a level close to the nominal current. However, a synchronous condenser has an innate fault current response defined by its electrical parameters. The result is that the delivered fault current can be high in amplitude, possibly even five times the nominal current or higher.

Voltage regulation — Like other synchronous and asynchronous technologies, a synchronous condenser can deliver megavolt amperes reactive (MVAr) for voltage regulation. In an under-voltage condition, where the voltage is becoming too low, reactive power is exported to support the system voltage. Equally, in an over-voltage condition, where the voltage is becoming too high, reactive power can be imported.

Capacity and Construction

Typical synchronous condensers have been manufactured with ratings of around 80 MVAr with a 10-20 kV machine voltage. The selected voltage is a matter of optimization as a step-up transformer is often used to suit the usually much higher connection voltage. Several condenser units can be connected to achieve higher outputs. This approach offers better redundancy and system availability than installing a single large unit.

The construction of the ABB - synchronous condenser is quite similar to a synchronous generator. It features a salient pole rotor, brushless excitation and epoxy resin insulated stator windings. The machine is water-cooled, but other options such as air cooling and hydrogen cooling are also possible.

High-Inertia Solutions

Lister Drive Greener Grid Park is ABB's first project to feature a high-inertia condenser configuration. This approach couples

a 67 MVAr condenser with a 40-ton flywheel.

Combining a mid-size synchronous condenser with a flywheel has the important advantage of multiplying the available inertia by several times. At the same time, the losses may be lower compared to installing the whole inertia as a synchoronous condenser. It is also a cost-effective way of using two mid-sized condensers together with the benefits of a high level of redundancy, increased inertia and greater controllability.

Together, the two units at the Lister Drive Greener Grid Park in Liverpool will provide a total of more than 900 MW-seconds inertia. That means Lister Drive will provide about 1% of the UK's projected minimum total inertia requirement for 2025. The condensers were commissioned in March 2023.

Aerial view of Lister Drive Greener Grid Park. Photo provided by Statkraft.

To ensure round-the-clock availability for this vital system, Statkraft has signed a 10-year services contract with ABB's UK field service team to provide a full range of maintenance services, both planned and quick response. Digital condition monitoring solutions will be deployed to optimize performance and predict maintenance needs. By assessing real-time data with cloud-based analysis, the team will be able to plan corrective actions before issues occur, ensuring system reliability.

A Green Solution

Renewable energy continues to make rapid progress in the UK and this success has created some challenges for the power system. On occasions it has been necessary to shut down wind farms and start up gas power plants to keep the system stable. Synchronous condensers promise to make this a thing of the past by maintaining stability without consuming fossil fuels.

Located at strategic points on the grid network, condensers will be able to help prevent power outages, ensure stability and most importantly reduce greenhouse gas emissions from electricity generation with associated cost reductions for consumers.

The UK's transition to 100% zero carbon electricity and the consequent decommissioning of large synchronous generating plants powered by fossil fuel has resulted in the need for innovative solutions to deliver system inertia vital for system stability. Statkraft's Greener Grid Park Project in Liverpool is using ABB synchronous condensers that will help to restore this balance. TDW

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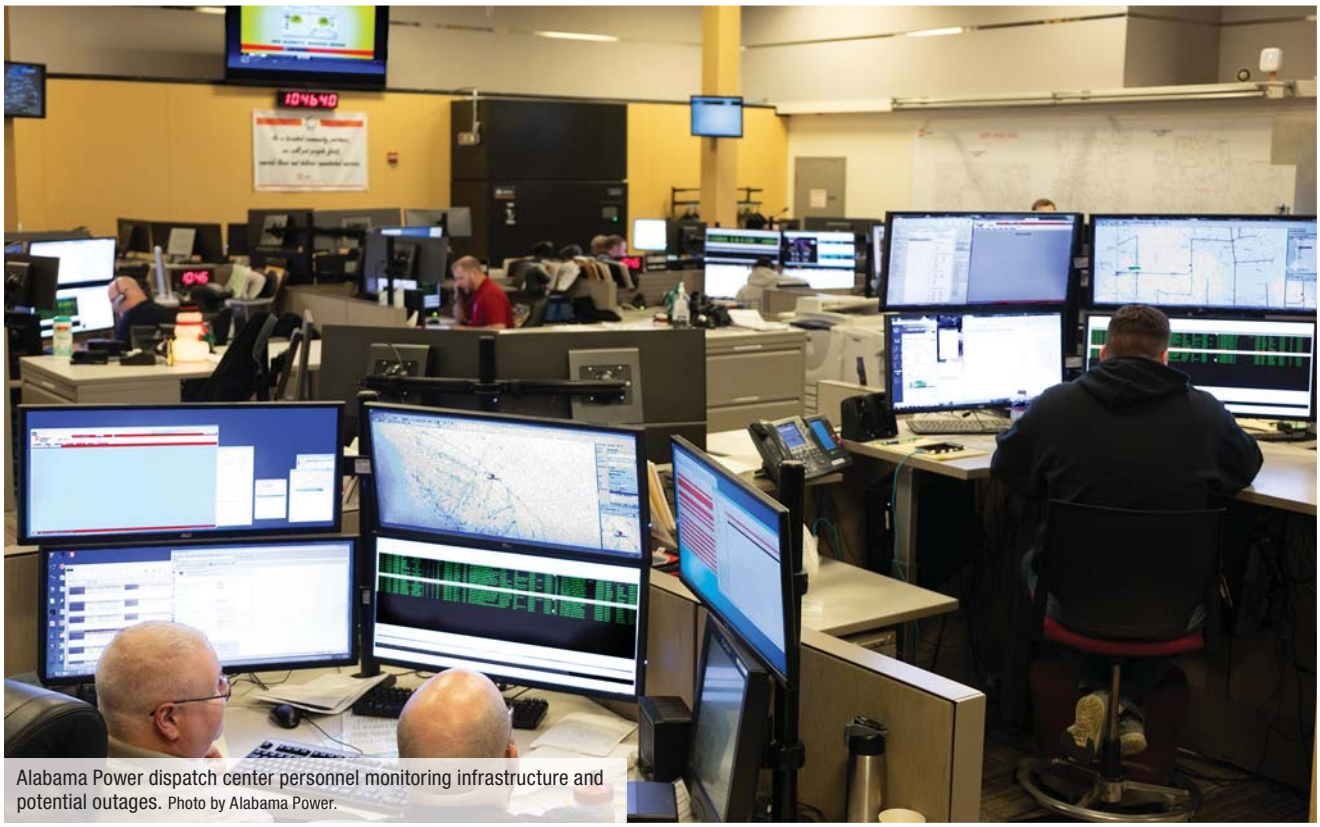


Alabama Power dispatch center personnel monitoring infrastructure and potential outages. Photo by Alabama Power.

A Mobile Platform For Efficient Restoration

Alabama Power finds success by taking a platform approach to its mobile workforce management strategy.

By **CHRIS MCCLAIN**, Alabama Power

According to technology research firm International Data Corp., "By 2025, 50% of utilities will implement a platform approach to operations, integrating core applications, improving visibility, management and efficiency to boost tight operating margins."

The electric utility industry is innovative in many areas. Utilities build resilience with advanced distribution management systems and fault isolation/service restoration technologies, map circuits with robust geographic information systems (GIS) and manage outage restorations during storms with integrated outage management systems (OMS). However, the industry has been slow to realize the full potential of technologies on mobile devices in the field, holding back the benefits of a platform approach to mobile workforce management.

For an industry that needs to be able to move the right people and resources where they are needed the most urgently, agility and accuracy are important. One way to achieve that is to adopt new tactics and technologies that enable smoother, more efficient deployment of those assets across service territories.

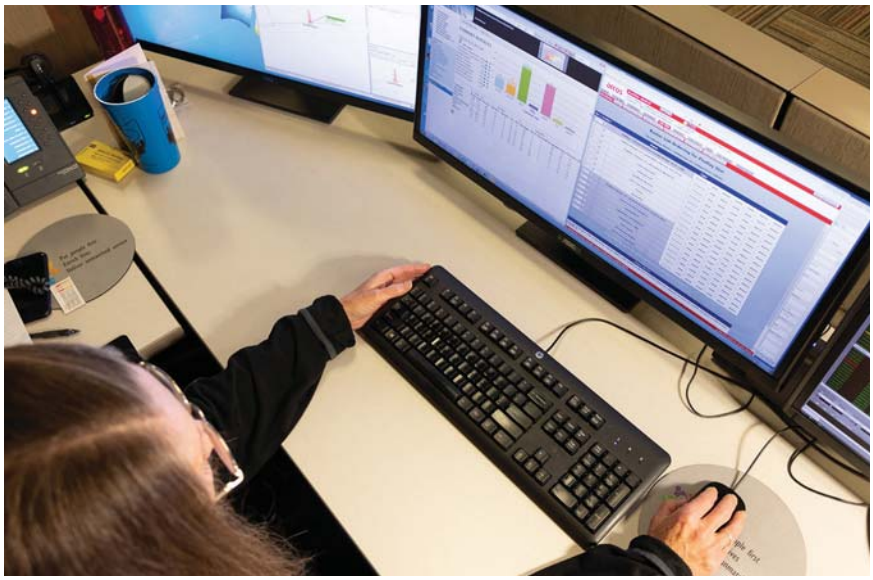
The Paper Problem

Unlike most construction projects, T&D systems are dynamic, so an as-built diagram that has a good shelf life for some sectors becomes rapidly out of date in the electric utility industry. This shorter shelf life presents utilities with a serious paper data problem.

Consider a service area with 1750 circuits and 70 field offices, each location servicing between 20 circuits and 30 circuits. Keeping five copies of each feeder map on hand in this scenario means a utility would need to maintain about 9000 copies. Furthermore, for utilities with multiple operating companies, this number could reach as high as 45,000.

The paper data problem becomes even more challenging during restoration — when hundreds, or even thousands, of

non-native crew members arrive, putting copy machines into full-time duty. In the wake of such an event, damage assessors carry their paper feeder maps to the field. They add handwritten notes, which must be transcribed into an OMS at the end of the day. Paper feeder maps delay the damage assessment process, and therefore restoration, because managers can only prioritize repairs once an assessor's notes have been entered.



A dispatch coordinator scrolls crew rosters, while scanning outage management system. Going digital and eliminating the mountain of paper feeder maps is not the entire solution to mobile workforce management during a storm response. Photo by Alabama Power.

Start Small, Scale Big

Simply put, mobile workforce management is the set of processes and technologies deployed across enterprises to support and empower mobile workers as they perform their jobs. Whether it is field reps providing daily service or crews performing line work, mobile workforce management is playing an ever-increasing role. However, going digital and eliminating the mountain of paper feeder maps is not the entire solution to mobile workforce management during a storm response.

Organizations need to address a wider variety of components in their mobile workforce management strategy, including secure access to GIS data, integration of outage management, and connecting the field and back office for a shared view of damage assessment and repair. To get there, start small and scale big.

Alabama Power originally provided tablet PCs — basically, laptops with screens that folded all the way back and came with a stylus — to field personnel. However, they were so cumbersome, employees often left them in the vehicle, opting for traditional methods of handwritten field notes followed by desk-based computer work with a keyboard and mouse. The utility also mounted

Line workers prepare for their next job by loading pole-mounted transformers onto trucks. Photo by Alabama Power.

Mobile workforce management is the set of processes and technologies deployed across enterprises to support and empower mobile workers as they perform their jobs. Photos by Alabama Power.

ruggedized laptops in vehicles for certain employees. While it has continued this approach with some work groups, it is often limited to ticket-based work assignments and rarely are those devices taken from the vehicle and toted around.

Alabama Power then chose to pilot first-generation iPads. The clear argument against such devices was that the utility has legacy Windows applications. However, this became a moot point because field workers were not leveraging the utility's legacy systems while out in the field. They came back to the office to use those systems.

The utility experienced the following benefits of using iPads:

- Always on (no bootup time), easy to carry, true touch-screen mobile interface.
- Inexpensive yet durable, especially compared to rugged laptops.
- Always connected with built-in LTE, so no dealing with Wi-Fi-only issues or tethering.
- Great for navigation to assets with built-in GPS and leveraging location-based apps.
- Seemingly endless supply of third-party apps to meet the utility's needs.
- Device-agnostic, web browser-based apps reduce downside of native apps.
- Larger screen size than a phone for viewing maps, for example.
- Can double as a laptop with keyboard, mouse and virtual Windows desktop.

When Alabama Power gave iPads to a group of line workers and the engineering staff they work with, these workers discovered other benefits. In addition to the aforementioned benefits, these workers found they could do some amazing things:

- Document conversion — All of the utility's construction standards, spec books and safety manuals were converted to PDF documents, reducing the binders of printed documents stored and updated on every truck across the system. They are now always available, up-to-date and searchable.
- Paperless processes — Construction drawings, work estimates, material lists and time sheets among other documents

A foreman uses a mobile app on the job. Alabama Power workers use mobile devices for document conversion and transmissions, as well as paperless work processes. Photo by Alabama Power.

were saved to a SharePoint site, so the workers could access them from the iPads. PDF design drawings could be easily marked up and forms easily filled out with PDF editing apps.

- Document transmission — Completed work could be saved to SharePoint, uploaded elsewhere or emailed.

Finding Success

Alabama Power quickly found more ways to use iPads by simply making data accessible to them, including GIS mapping information, asset/equipment historical data and operations manuals, customer reliability information, meter demand information, customer outage information, and various reports and dashboards.

These quick-and-easy wins gave field personnel information at their fingertips, enabling them to work more safely and efficiently and provide better customer service. It was a grassroots effort that led to broader adoption. This success created an appetite within the field workforce to pursue even more mobile opportunities.

Despite the success, Alabama Power also had to face challenges: The utility had to manage the development of a mobile workforce management strategy that eliminated app overload for line workers; brought systems and people together; and maintained the security of proprietary information. Importantly, integrating mature GIS capabilities and making a significant investment were critical to the utility's strategy for meeting these challenges.

A Platform Approach

The electric utility industry must keep striving for a platform approach to technology, especially regarding mobile workforce management. An investment in mobile workforce solutions will help to create a utility operating system that integrates and leverages a power provider's blue-sky and storm-response digital ecosystem. TDW

CHRIS MCCLAIN is the team leader for power delivery technology at Alabama Power. His more than 22 years of experience includes distribution engineering, planning and mobile technology support for utility field workers. McClain earned his BSEE degree from Mississippi State University and his MBA degree from the University of Alabama at Birmingham.

Rugged Laptops

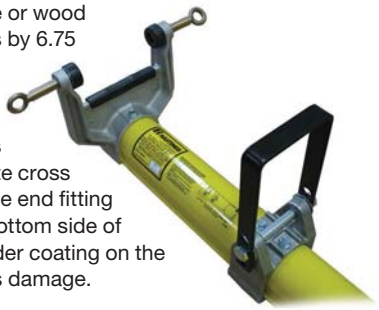
Getac Technology Corp. has launched its next-generation B360 and B360 Pro fully rugged laptops. The pro laptops feature a wide range of upgrades and refinements simplifying difficult computing tasks in demanding conditions. Key features include an upgraded Intel Core 12th generation i5/i7 processor with integrated Intel Iris Xe graphics, for performance, responsiveness, and rich visuals. A 256GB PCIe NVMe SSD as standard (with option of up to 4TB) offers ample storage, while the 13.3-in. FHD LumiBond display with Getac Sunlight Readable Technology (1,400 nits) and capacitive touchscreen helps maintain productivity around the clock. The B360 Pro takes this even further, with optional NVIDIA GeForce GTX1650 4GB discrete graphics controller, plus an optional media bay that can accommodate a third SATA SSD (for up to 6TB storage capacity), third battery, or a DVD drive as required.

Both the new B360 and B360 Pro also offer extensive connectivity options, keeping users connected in remote or isolated environments. These include Wi-Fi 6E AX211, 802.11ax, and Bluetooth 5.3 as standard, as well as optional 4G LTE or 5G Sub-6 with integrated GPS.

GETAC | *www.getac.com*

Fiberglass Cross Arms

Hastings' Fiber Glass Extension Cross Arms are available with up to two standard conductor holders or large capacity holders. Retrofit kits are available to convert existing extension arms to the Standard or Super "U" Arm configurations. The fiberglass extension arms fit composite or wood cross arms up to 4.25 inches by 6.75 inches and are usable with Hastings' Round and Super "U" Extension Arms. Rubber grippers on the arms prevent damage to composite cross arms while casting trim on the end fitting provides protection on the bottom side of composite cross arms. Powder coating on the cross arm loop also prevents damage.



Hastings | *www.hfgp.com*

Transformer Digitalization

Hitachi Energy has launched the next-generation TXpert Hub, a part of its ecosystem for transformers' digitalization. The TXpert Hub enables monitoring by aggregating, storing, and analyzing the information received from the transformer's digital sensors.

The TXpert Hub, powered by the latest CoreTec technology, has been built from the ground up to ease transformer digitalization, focusing on:

- Incorporating the operative experience from users of earlier versions of the system
- The application of the latest technologies in communications and cybersecurity

- Readiness for off-the-shelf retrofits

TXpert is Hitachi Energy's open, scalable, manufacturer-agnostic ecosystem for the digitalization of transformers, designed to drive data-driven intelligence and decision-making in the operations and maintenance of transformers. It is a complete suite of products, software, services, and solutions that work together and have the capability to integrate with new and existing digital equipment from other manufacturers. Spanning all types of new or existing transformers – distribution, dry and power transformers – the TXpert Ecosystem includes:

- TXpert-Ready digital sensors: Such as temperature, DGA, bushings...etc from an extensive list of proven TXpert Ready third-party sensors
- TXpert Hub monitoring system: Powered by CoreTec. The TXpert Hub provides asset level data visualization, acting as a watchdog and interface for all the sensed data
- Asset Performance Management software: On Cloud, Edge or Premise Software that uses the data for actionable insights
- TXpert advanced services: To have further expert insights and help it act instantaneously

Hitachi Energy | *www.hitachienergy.com*

Protection and Control

ABB has launched the first virtualized protection and control solution with Smart Substation Control and Protection SSC600 SW. The virtualized product enables customers to use the hardware of their choice and gain access to the same protection and control functionality as with ABB's turnkey solution. One SSC600 device can handle the tasks of 30 protection relays. Centralizing this functionality in the substation reduces network complexity and supports optimal, lifelong asset management and up to 15% savings in substation life cycle costs. To create a robust power system protection and control solution that provides the flexibility and enhanced resiliency necessary to face increasingly complex grids, SSC600 SW supports Linux KVM and the VMware Edge Compute Stack platform featuring ESXi 7.x or later as virtualization environments and runs on Intel Xeon Gold processors to ensure real-time performance.

ABB | *www.abb.com*

Grid Management Software

GE Digital has announced end-to-end software portfolio, GridOS, built specifically for grid orchestration. Designed to modernize and transform the electric grid into the clean energy grid of the future, GridOS is a platform and application suite enabling secure and reliable grid management while delivering the resiliency and flexibility needed by utilities worldwide. GridOS integrates energy data, network modeling, and AI/ML-driven analytics to power a suite of intelligent applications developed by GE, utilities, and GridOS partners. The GridOS® orchestration platform includes:

- Zero Trust grid security model applied throughout the platform to protect resources from inside and outside threats.
- Federated grid data fabric with a common transmission and distribution model to enable a grid digital twin.
- A suite of intelligent grid applications that evolve and modernize the grid control room for proactive and automated grid management.

- A hybrid cloud architecture to deploy and scale applications where they are needed – on-site or in a hybrid environment.

GE Digital | *www.ge.com*

Thermal Imaging Sensor

Systems With Intelligence has launched the TS3700, a utility-grade thermal imaging sensor that can withstand the harsh environments in electric power applications. The TS3700 Advanced Smart Sensor is engineered for utilities who want built-in temperature analytics and alarms for asset condition monitoring and early detection of temperature anomalies. These sensors feature a protective housing that can withstand extreme temperatures, providing a high level of protection against challenging environmental conditions. The TS3700 features a high-resolution lens and can provide accurate temperature readings on hundreds of points, of any size and shape. The sensor can be setup to automatically scan the remote site with its programmable pan and tilt base and provide alarms through email or to the SCADA system.

Systems with Intelligence | *www.SystemsWithIntelligence.com*

Underground Distribution Restoration

S&C Electric Company has launched its EdgeRestore Underground Distribution Restoration System, which dramatically improves customer power reliability by mitigating outages and eliminating emergency truck rolls on underground residential distribution systems. When an underground fault occurs on an underground residential loop, the EdgeRestore system automatically locates and isolates the fault and reroutes power from an alternate source—all within 60 seconds. This intelligent system reduces the impact of sustained outages that commonly last for hours and eliminates the need for immediate crew intervention, keeping power on until the underlying issue can be resolved. Automatic fault isolation also greatly simplifies the process for locating faults on underground residential circuits and reduces medium-voltage exposure for crews. The EdgeRestore system is easy to deploy, with smart communication across existing power cables. It fits inside the transformer enclosures on new or existing underground residential loop circuits, with no changes to the normal protection scheme. The devices do not need any programming, firmware updates, computers, Internet connectivity, batteries, radios, or antennas.

S&C Electric Co. | *www.sandc.com*

Safety Headlamps

For professional trades like utilities, Princeton Tec's industrial-grade VIZZ series headlamps are designed to provide powerful, lasting, reliable, hands-free illumination to increase operator safety and productivity in the many low-light work conditions that require it. Princeton Tec designs and manufactures its headlamps in the U.S. with durable thermoplastic material engineered to withstand drops and rough handling. An IPX7 waterproof rating means the headlamps are thoroughly protected from moisture, providing

waterproof integrity down to 1 meter for up to 30 minutes. The 3.2oz VIZZ series headlamps flexibly light up the workspace with two separate modes that the operator can easily switch between at the push of a button: flood, which widely illuminates the surroundings, and spot, which focuses a bright beam on the task at hand. The operator can dim and adjust the light level to their personal preference in both modes by holding down the pushbutton to the desired setting. The dimming capability also extends battery life. The raised button provides ease of use when the operator is wearing gloves. Since battery life is an important consideration for technicians working 8-to-12-hour shifts, VIZZ series headlamps offers consistent regulated LED illumination. Traditional lights are very bright initially, but immediately begin to dim and continue to dim until the batteries are drained. These headlamps come with an industrial headlamp kit with a nylon head strap, a rubber hard hat strap, and double-sided Velcro to affix the light to a helmet, if preferred. Three AAA batteries are included.

Princeton Tec | *princetontec.com*

Crane Pads

In response to industry demand for durable and engineered equipment stabilization at a lower price point, DICA is introducing EcoMax Crane Pads. EcoMax Crane Pads combine alternating solid composite "timbers" and steel I-beams connected with through-bolts for maximum load distribution. This patented product has similar stiffness, strength and performance properties as DICA's FiberMax Crane Pads or steel pads but is less expensive than either of those options. EcoMax is suitable for distributing concentrated loads from equipment with outriggers, such as mobile cranes, concrete pump trucks and self-erecting tower cranes. While EcoMax is heavier than FiberMax Crane Pads, it is lighter than solid steel mats. EcoMax Crane Pads are available in four sizes ranging from 20 to 40 sq ft with maximum rated capacities of 175,000 lbs. to 325,000 lbs., respectively. EcoMax Crane Pads are non-absorbent, easy to clean and resistant to rot and decay, providing long-lasting and predictable equipment support.

DICA Outrigger Pads | *www.DICAusa.com*

Mini Access Point

Itron has unveiled its Fiber Mini Access Point (Fiber MiniAP), which leverages both fiber and RF mesh connectivity for a wide range of Itron endpoints. The Fiber MiniAP can help cooperatives leverage fiber network assets for next generation advanced metering infrastructure (AMI), distributed intelligence, distribution automation, low-voltage network management, smart lighting and more to enable grid modernization beyond meter-to-cash. Rural electric cooperatives often recognize the synergy and interdependency between broadband and smart grid networks and in many instances face the challenge of building these networks in more sparsely populated areas. By leveraging fiber assets, the Fiber MiniAP extends industrial IoT (IIoT) network coverage in rural areas with low meter-per-mile density while reducing infrastructure and total cost of ownership, both of which are common obstacles to cooperative network upgrades.

Itron | *www.itron.com*

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Alabama Power @ alabamapower

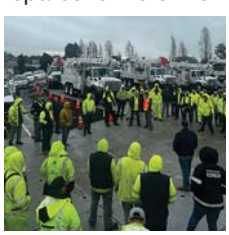
Our teams plus 500 additional resources have been working as quickly and safely as possible through the night and this morning.

Florida Power & Light Company

Thanks for having our robotic dog SPOT and FPL Project Manager Kyle Bush at your Middle School Career Expo, PLANitSarasota and Education Foundation of Sarasota County! Kyle enjoyed inspiring and being inspired by potential future engineers.

SCE @SCE

As SoCal prepares for #storms this week, @SCE crews are ready to respond to weather-related issues. A select crew has also deployed north to support @PGE4Me in Santa Cruz.



Baltimore Gas and Electric

This #WorldWildlifeDay, we celebrate our commitment to protecting and preserving local wildlife throughout our service area. In 2022, 12 osprey nests on BGE equipment were reported to us, allowing our crew to safely relocate the nests and preserve the osprey's habitat and our equipment.

NV Energy

NV Energy line crews volunteered at Kitty Ward Elementary and Claude & Stella Parson Elementary last week to participate in their Career on Wheels events. Students learned about a day in the life of a line worker, interacted with equipment and each received an activity book on future careers in energy.

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Bringing Broadband to Underserved Communities in Upstate New York

Mark Thompson

Jeff Gasper

During the height of the Covid-19 pandemic, the importance of broadband internet connectivity became glaringly obvious for many of us. As offices, schools and businesses closed and stayed shuttered for weeks and in some cases months, many of us were or still are working or learning remotely. In parts of our country, however, there are areas where broadband connections are limited or non-existent, and those communities, typically in rural areas, suffered.

The broadband revolution, which has created boundless opportunities in education, communication and entertainment, passed by less populated parts of New York as well as the country as a whole. Because of the cost to private broadband companies to build connectivity to rural areas, large providers have missed many rural communities or homes.

At the same time, New York State is transitioning to newer forms of clean energy. These newer forms of clean energy and the accompanying modernization of the grid require enhanced monitoring and communications that are best served using broadband connections. Now is a critical time to address the issue of community broadband deployment in New York while enabling the transition to clean energy.

Last fall, National Grid partnered with the Development Authority of the North Country (DANC) and Southern Tier Network (STN) to submit two proposals to the National Telecommunications and Information Administration (NTIA) for middle mile infrastructure funds to expand broadband access and affordability in parts of New York, while building an improved, digital network across our electrical grid in the state. The proposals, if chosen by NTIA, would be funded by The Federal Infrastructure Investment and Jobs Act.

The partnerships among DANC, STN, and National Grid bring together two sets of expertise: DANC and STN bring experience delivering critical open-access middle-mile broadband services to homes and businesses across their region; National Grid owns and operates hundreds of miles of utility pole infrastructure that helps deliver those critical services, while also providing electricity for thousands of residents of upstate New York.

In partnering with DANC and STN, National Grid hopes to address two issues with one solution: to help bridge the digital divide while enhancing the electrical infrastructure in rural areas on which so many depend. DANC, a state public authority, and STN, a 501C3 nonprofit, were both created to support their regions and are experienced in delivering open-access middle-mile infrastructure to drive low-cost broadband within their respective communities.

National Grid is certainly not getting into the broadband business. But the proposed projects would use federal funds along with National Grid capital to build out shared fiber optic infrastructure in locations in upstate and western New York to provide middle-mile capabilities for internet service providers, connectivity for community anchor institutions, and communication infrastructure for the energy system.

For National Grid, the energy transition is seeing a national and regional shift to renewable energy and battery storage. As such, modernization of the grid requires digital communication to support the novel technologies and provide faster response times when issues impact the electrical grid. Systems are becoming more intelligent, interconnected, and consumer-centric. Electric and gas networks are no longer operating on their own, but with the support of a robust data network. The expansion of this data network is critical to ensure real-time power system and market data is available to maintain the reliability, security, and safety of the electricity grid. As that transition continues, the need to harden and enhance the electrical grid and its communication network has grown — especially in rural areas.

STN and DANC have been addressing the need for broadband service to homes and businesses in rural areas for years. Despite large public investment in addressing this need, service to many areas with low populations is still lacking due to the economics of building and maintaining service to a handful of homes. This partnership with National Grid, if NTIA approves, helps build in these rural areas as the costs are borne not just the broadband consumer but also the electric consumer who benefits from the increased connectivity.

These partnerships also help address a key challenge that often occurs when delivering broadband infrastructure. Broadband projects can require extensive make-ready support to prepare the utility poles for the new fiber optic cables, which can be expensive, approximately 40% of the total project cost. These make-ready costs can make it challenging for projects to be financially sustainable for broadband providers who must bear the investment in make-ready infrastructure. This project is different in that the electric customers are directly benefiting from the new infrastructure and so is National Grid, as the pole owner and the electric utility who is receiving a portion of the fiber install. By sharing these fiber assets, electric customers will be receiving infrastructure required for the power grid at a discounted rate, and the installation costs are reduced for DANC, STN, and ultimately the broadband consumer.

By enhancing that connectivity, the New York electric grid would have greater capacity to integrate new renewable energy resources, respond faster to outages, and operate more efficiently. Modern power system protection technology with high-speed communication between substations can support high levels of renewable energy generation. TDW

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