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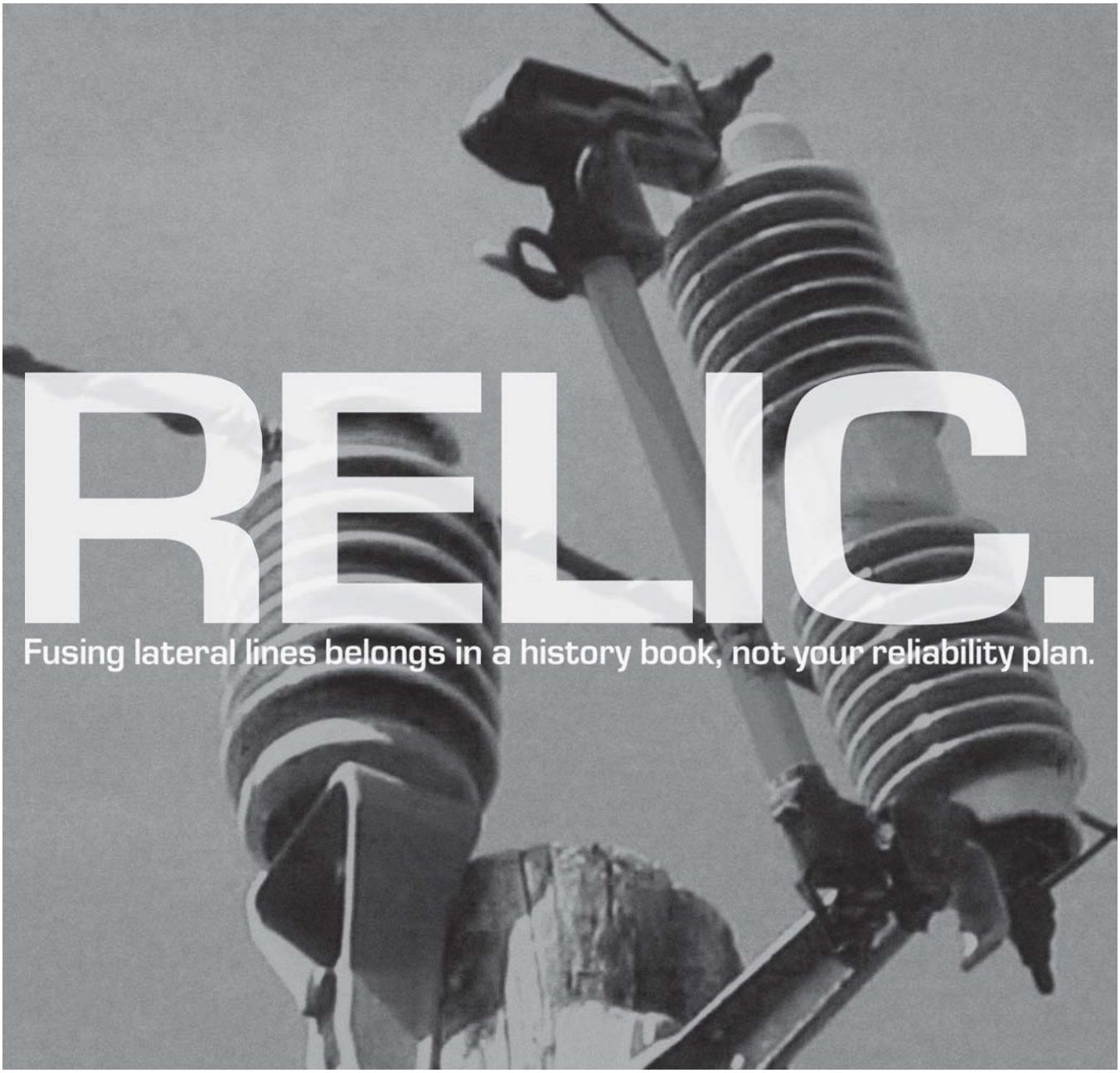

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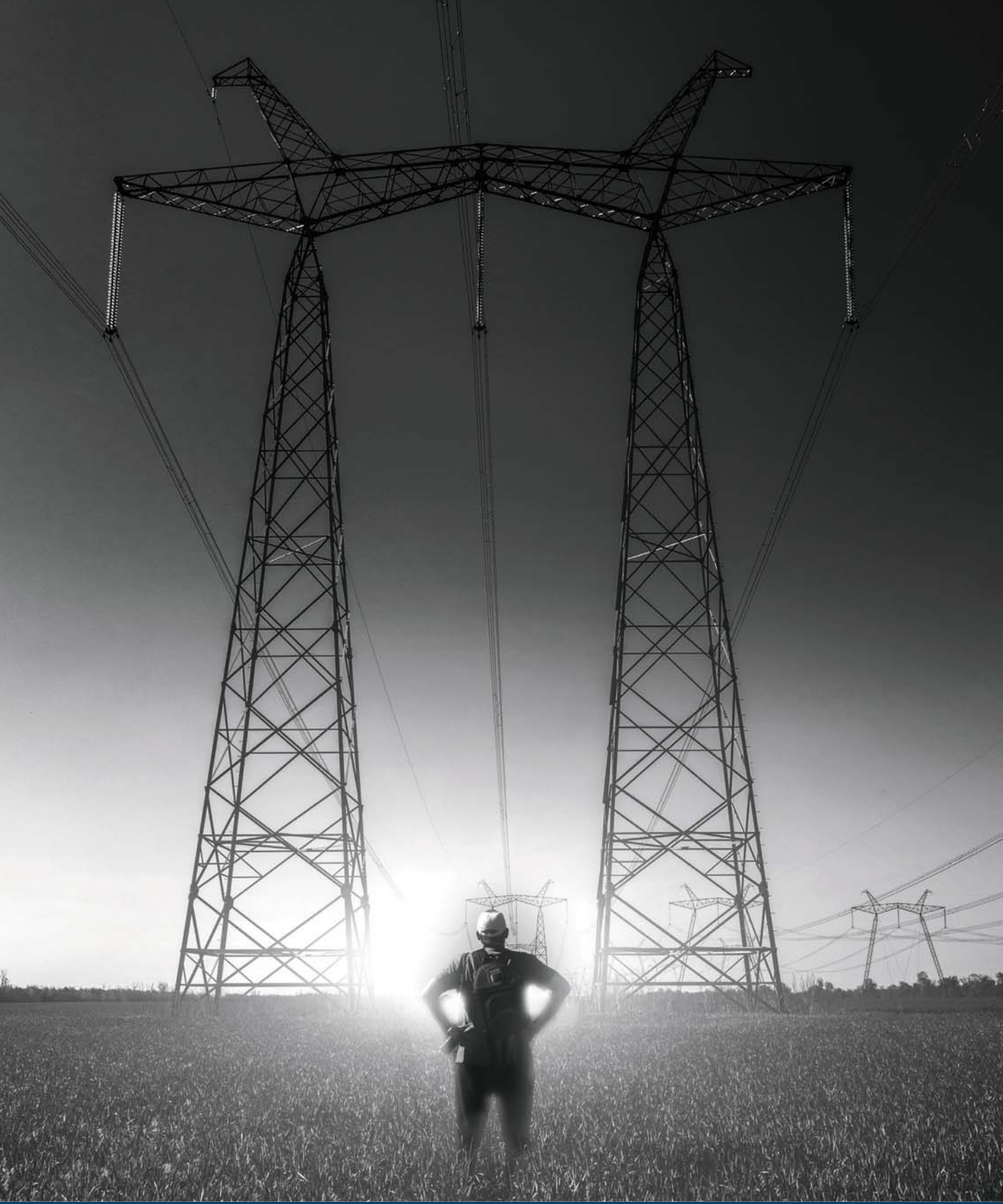

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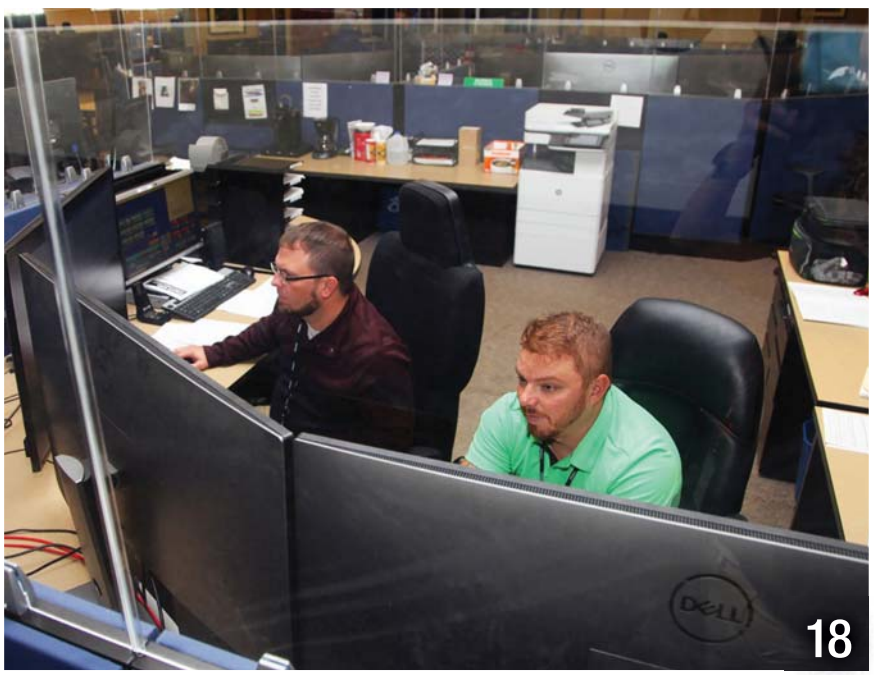

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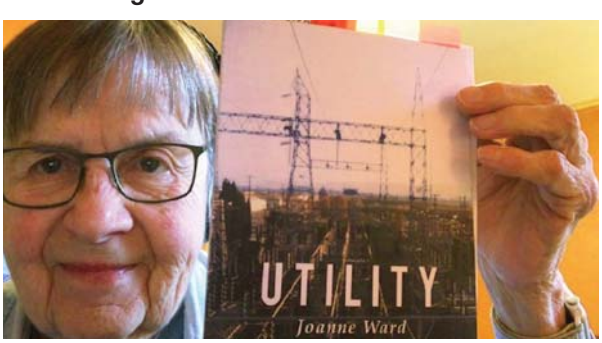

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Microgrids: Utility Friend or Foe?

Microgrids are seen by some large energy users as a solution to meet sustainability goals, ensure resiliency, and in a few instances, replace their dependency on traditional utilities. Many utilities see them differently — as a competitor and a threat. Some utilities, however, are learning that microgrids can help them improve grid reliability and resiliency and mitigate capacity restraints. I recently attended Microgrid Knowledge 2023, an event that *T&D World's* parent company Endeavor Business Media acquired last year. This one-of-a-kind event covers all things microgrid, including what some of the largest utility companies in the U.S. think about microgrids and how they are integrating them into their grids of the future.

One panel session titled "Friends or Foe? The Future of Utility Microgrids" featured three investor-owned utility representatives: Jason Handley, Duke Energy; Chris Lynn, Arizona Public Service Co. (APS); and, Jeremy Donnell, Pacific Gas & Electric (PG&E). It became clear early in the discussion that whether a microgrid is a utility's friend or foe relies heavily on application and state regulations.

Duke Energy has completed and is operating two microgrids. It has five additional microgrid projects in progress, according to Handley, who said microgrids can be both friend and foe. Handley explained that in most of Duke's service territories, the utility is ultimately responsible for grid reliability and has been for 120 years. Therefore, Duke has much to consider before installing its own microgrid, or integrating another company's microgrid. "I'm not a dinosaur. I think we need microgrids and other DERs (distributed energy resources) and I'm positioning us (Duke) to accept all forms of DER," he said. But Handley also stressed that the application or use case must show that the microgrid is the least-cost service option and will be available, resilient and reliable. Duke Energy must always consider what is best for the grid and its customers.

Chris Lynn had a different opinion. He said microgrids are friends. They provide APS with the opportunity to add capacity and keep money in the communities they serve, which in turn creates economic resources that help APS. Lynn also talked about a buyback program that allows APS to buy into onsite generation with end-use customers. The utility in certain areas is working with hospitals and other large energy users, encouraging them to install microgrids. In successful installations, APS can work with the customer to get dispatchable power exactly where they need it. One caveat: "Everyone must understand the rules."

Jeremey Donnell, who represents the largest utility in California, said that "unequivocally" microgrids are friends, if they are safe, reliable and affordable. Donnell's outlook is not a surprise when you consider that as early as 2018, California legislators began creating laws that promote the use of microgrids. Lawmakers created a bill that directed the state's Public Utility Commission (PUC) to work with the California Energy Commission and CAISO to create regulations that accelerate microgrid deployment and related resiliency solutions The PUC also authorized in January 2021 a $200 million Microgrid Incentive Program to fund clean energy microgrids to support critical needs and to test new technologies and regulatory approaches to help with future infrastructure planning. So, it's reasonable for PG&E to be outpacing other utilities when it comes to integrating microgrids into their business and resource plans. Donnell highlighted PG&E's Blue Lake Rancheria Microgrid Project as a solution that delivers clean, reasonably priced electricity to a remote area without adding constraints to the utility's transmission system, all while mitigating wildfire risk and increasing resiliency.

This one friend-or-foe question early in the discussion illustrated the unique and somewhat opposing opinions related to utility-scale and utility-owned microgrids. Later discussion, however, revealed that the three gentlemen on the panel also agreed on a lot, including:

1. Microgrid adoption at utilities is in the early stages, and there is still much to be learned.

2. Microgrids are too expensive in most cases, and costs must be lowered.

3. There are opportunities to improve on deployment and interconnection.

4. FERC's interconnection process requirements take too long and must be streamlined. They have been known to cause three or even four-year delays.

5. Supply chain issues exist. The industry needs to work with suppliers to speed delivery of equipment and components.

The need to get away from serial/custom installations was identified throughout the event as one of the biggest challenges. I heard more than once "If you've seen one microgrid, you've seen one microgrid." It was obvious, however, that the attendees at this event, which were primarily large energy users, project developers and component and software companies, firmly believe that microgrids are the future. They see them as the answer to capacity constraints, a reliable and resilient power source, and key to electrification and zero carbon energy.

Time will tell if this vision is true. I think microgrid use and adoption will continue to vary from utility to utility and state to state for several years. With or without utility participation, microgrids will be a part of the energy future.

If you want to learn more about microgrids, I encourage you to visit *www.microgridknowledge.com.* We will also be covering utility-scale microgrids at our T&D World Conference and Exhibition this September. There you can learn more about Duke Energy's experience with inverter-based microgrids, as well as hear representatives from Cobb EMC and the city of Lodi, California, discuss their microgrid installations.

Details are available at *www.events.tdworld.com.* TDW

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IEA: Solar Energy Investment Topping Fossil Fuels Worldwide in 2023

Solar power investment is going sky high and double-fisted these days.

A new report by the International Energy Agency estimates that investment in clean, carbon-reducing energy technologies will top $1.8 trillion around the world in 2023. Solar power accounts for a record $1 trillion-plus this year, perhaps topping even the long-king oil and gas industries, according to IEA's world energy investment report.

That's the sky high part. Reaching and topping $1 trillion, or ten digits, is the double-fisted part for the solar power movement.

"Clean energy is moving fast — faster than many people realize," IEA Executive Director Faith Birol said in the release accompanying the group's report. "This is clear in the investment trends, where clean technologies are pulling away from fossil fuels."

Photo 41317153 © Airubon | Dreamstime.com

The tabulations from worldwide energy ministries, developers and investment firms highlight a curve estimating that clean energy spending has been rising 24 percent from 2021 through the end of this year. Renewable energy projects both on the macro and microgrid side, as well as electric vehicle and charging infrastructure spending, account for the majority of that growth, according to the IEA.

The paths to Net Zero are many, from investment in renewables and EVs to hydrogen, carbon capture, small nuclear, battery storage and building energy efficiency tools. The move toward decarbonization in developed economies has sustained a momentum which does not seem to be slowing down.

That is not to say that fossil fuel investment is fading to zero, net or gross, anytime soon. Projects around coal, natural gas and oil are still attracting more than $1 trillion and have risen 15 percent from 2021-23, according to the IEA. The overwhelming majority of that fossil-fuel project growth has come from large and developing nations such as China and India, the IEA says.

This trend "presents a serious risk of new dividing lines in global energy if clean energy transitions don't pick up elsewhere," the IEA release reads.

This worry was stressed by private equity giant BlackRock founder and CEO Larry Fink in a talk during the Global Energy Summit last month at Columbia University. The energy transition investment may require $100 trillion or more to reach Net Zero goals by 2050, but Fink acknowledged the dangers of rich nations forgetting what developing nations need to join in the transition.

"We're really not being truthful to ourselves," Fink said in the interview with Jason Bordoff, founding director at the Center for Global Energy Policy at Columbia's School of International and Public Affairs.

"This is where I'm an alarmist," Fink admitted. "If we want to be faithful to this (goal) we need emerging countries to come along with us."

And yet China also is a global leader in EVs and builds more renewable capacity that the U.S. in overall dollars equivalent, if not per-capita spending. So the pace of decarbonization, while not completely headwind-free, is inspiring much optimism among global energy leaders such as the IEA's Birol.

"For every dollar invested in fossil fuels, about 1.7 dollars are now going into clean energy," he pointed out. "Five years ago, this ratio was one-to-one. One shining example is investment in solar, which is set to overtake the amount of investment going into oil production for the first time."

Yet the tide has hardly turned completely. Current fossil fuel investment is more than twice the level needed in key Net Zero Emissions by 2050 calculations, the IEA warned.

Oil giants are reaping the benefits of higher prices, with U.S. leader ExxonMobil reporting $56 billion in earnings last year. Yet even ExxonMobil, while still reaping the benefits of profitable drilling fields, is committed to investing in clean energy technologies.

One of those was a $125 million investment in renewable diesel development announced last year. Companies such as ExxonMobil and Shell also are exploring carbon capture, utilization and storage projects to offset and mitigate oil and gas emissions. TDW

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The Future Is Nearer

My favorite robotics newsletter hit my inbox a few days ago and it was full of thought-provoking material. I was looking for any articles about robots used for autonomous inspections, so I did a speed-read of its contents. There were a couple of possibilities, but there was an article displaying NASA's logo that caught my attention.

NASA was excited about the ongoing adventures of NASA's Mars rover Perseverance and the robot helicopter Ingenuity. Ingenuity had set a milestone. I admit, it was a bit of a side trip, but the graphics demanded a closer look. This isn't the first time I have included this exploring duo in my writings. These robots represent cutting-edge applications in a trending technology that is having a massive impact on the power grid.

When NASA launched the mission, no one was sure a helicopter would be able to fly in the thin Martian atmosphere, but that didn't stop the NASA team. The science was sound, and the math was solid. In April of 2021, Ingenuity took its first flight proving the scientists and engineers were correct.

Exceeding Expectations

Powered, controlled flight on Mars was possible. Ingenuity was designed to have five flights, but when April of 2022 rolled around, Ingenuity was still flying and had completed flight #28. The little chopper had proven its adaptability. Ingenuity took on the role of being Perseverance's scout as it roved across the Martian landscape.

The robotic newsletter opened with a headline proclaiming Ingenuity had flown its 50th flight in April, 2023! Ingenuity had broken all records with over 89 minutes of flight and had covered more than 7.1 miles (11.6 kilometers). In other words, every time Ingenuity flies, it goes where no one has gone before, providing a viewpoint never seen before. It also means that Ingenuity's scouting effort was becoming more challenging.

The intrepid duo has moved from the flat landing site to a terrain of the ancient river delta in the Jezero crater with ravines and many elevation changes. NASA's engineers had to change the way Ingenuity operated. Ingenuity needed input in the decision making if it was to continue as Perseverance's scout.

Simply put, Ingenuity's artificial intelligence (AI)-driven software needed more awareness. An upgrade was required, and it was extremely demanding. As I read about the technological challenges involved with keeping robotic duo operating together, it made the utilization of autonomous inspection robotics on the power grids sound pretty routine.

Perseverance's selfie with Ingenuity. Photo courtesy of NASA.

Boring is a Good Thing

When innovative technology starts sounding routine or boring, it's a sign that the technology has advanced to the point where people are no longer in awe of it. We are comfortable with it. It's another way of saying the technology is maturing and more user-friendly. Mainly, the technology is moving further into the mainstream, and becoming commonplace.

Manufacturers are offering systems designed specifically for the needs of industrial segments like the power delivery system. Boston Dynamics's Spot is an agile quadruped autonomous robot that is being used by utilities such as National Grid, TALEN Energy, Energie NB Power, and others for autonomous inspection tasks.

Siemens Energy, Elia Group, and Nemo Link with Foss Robotics are co-developing an inspection robot to go inside HVDC (high-voltage direct current) converter halls during operation. Being able to inspect energized valve halls reduces outages and improves personnel safety.

There are also scenarios here on Earth similar to those experienced by Ingenuity and Perseverance on Mars. Sometimes the inspection robot needs more information than can be provided by a remote operator. To perform its mission the robot really requires the freedom to make decisions based on conditions.

ANYbotics has an autonomous robot called ANYmal. ANYmal uses an augmented reality to guide its decisions even if there is an interruption in its GPS (global positing system) or a loss of internet access. Vattenfall, an integrated energy company, and Siemens Energy are testing ANYmal at the Marzahn power station. ANYmal takes advantage of advancements in real-time algorithms, AI, and cloud computing to make this possible.

A quick check showed the global market for autonomous inspection robotics is projected to grow by about 8.4% CAGR (compound annual growth rate) in 2023 with spending expected to reach US$4.2 billion by 2028. It's hard to imagine how NASA's Martian AI-driven decision making autonomy will improve our robotics, but it will. It may sound like science fiction, but the technologies exist to make it happen. I can't wait to see what's next! TDW

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Weathering Expanding Power Outages

AI-driven applications are focusing on reducing the growing problem of power outages.

Is there such a thing as a casual observer when it comes to vegetation management? Probably not! It's one of those subjects that everyone has a strong opinion, and the opinions run from conservative to liberal. There is, however, one commonality – all are demanding improvements. Why may you ask yourself? Because of vegetation management's relationship with power outages and grid resiliency has been made more complicated wildfires.

adventtr / iStock / Getty Images Plus

There probably isn't a casual observer when it comes to artificial intelligence (AI) either. As AI becomes more autonomous, it's raising strong opinions too. It's a concept that little attention is given. Most of our attention has been focused on driver-less vehicles. Many are concerned that the more autonomous AI becomes, the less humans will understand it and how it works, which will make it harder to control. Another worry is about AI controlled machines replacing humans.

AI Improves

To be autonomous the AI application needs analytical capabilities that allow it to operate independently from human control. To be clear, AI technology hasn't progressed as far as the science fiction seen in Marvel Universe. Today's autonomous AI is a specialized version of narrow AI or more specifically machine learning. AI's decision-making is controlled by algorithms or series of algorithms that are capable of analyzing the enormous amounts of big-data supplied by sophisticated remote sensing technologies used in systems like vegetation management.

This analysis is invaluable when it comes to finding patterns and specific information in the raw bigger-data common today, which is exactly what today's vegetation management needs. Like all of the current technology wearing the autonomous AI label, it needs some form of human guidance, but it's minimal compared to earlier generations. Suppliers such as AiDash, GE, Hitachi, IBM, Siemens Energy, and others are saying more intelligent platforms will revolutionize vegetation management. Opponents ask, is autonomous AI technology the answer?

Before answering that question let's look a little closer at what's taking place on the electrical power grid. Everyone is aware that there has been an upswing in electrical power outages, but why is that? Some critics say it's the way utilities are going about vegetation management. They are not being aggressive enough when it comes to clearing rights-of-ways (ROW), which is an obvious simplification that ignores a lot of collected data.

What's Up

Digging into the issue revealed that extreme weather events have changed the playing field when it comes to vegetation management. Risks are no longer confined to the vegetation along the power line rights-of-way (ROW), but go beyond the ROW. What once worked is no longer sufficient with extreme weather conditions on the rise globally. Climate change has worsened power outages! It's hammering the power delivery system with a recurring series of once-in-a-lifetime storms that the grid was never designed or constructed to handle.

Compounding the problem are vegetation management strategies intended for a normalcy that no longer exists. Also utilities have regulatory requirements to survey their transmission systems every year, but the interpretation all of the big-data takes time, so it is prioritized. That doesn't mean the data is ignored, but given the enormity of the transmission circuit

miles, it encourages time-based maintenance cycles for known problem areas, but how many miles are we discussing?

On a global scale that's a hard question to answer due to many factors, but North America is better documented. It's estimated there are about 200,000 miles (321,000 km) of high-voltage transmission lines. If distribution lines are included, somewhere around 5.5 million circuit miles (8.8 million km), which is reasonable because most authorities agree that the majority of interruption happen on the distribution system.

Spending's Up

Circuit miles are meaningless to the customers. They're only interested in keeping their lights on, and utilities are working hard to reduce those power outages. A recent study from Fortune Business Insights points out that globally utilities and grid operators spent US$24.28 billion in 2022 on vegetation management. Forbes continued saying they expect that spending to reach US$39.27 billion by 2029. Several other authorities report that vegetation management is the largest expenditure in the average utility's yearly operating budget, but it's not working because outages are on the rise.

That brings us to climate change and its impact on the environment, which has been defined as the major cause of electrical power outages. Supporting this statement is new SAIDI data from the U.S. Energy Information Administration (EIA). SAIDI is a reliability metrics and stands for the "System Average Interruption Duration Index." The EIA recently published its "Electric Power Annual 2021" in November, 2022 (Editor's note: the latest figures available).

One section was a real attention magnet. It focused specifically on power outages in 2021. EIA's data determined that the average U.S. electricity customer experienced just over seven hours of SAIDI defined power outages. The seven hour period represent all interruption events in 2021, but there is more. Reading further revealed that about five hours of the total seven hours, or approximately 71%, were attributed to major weather-related events.

It's Complicated

While there wasn't any further information defining those causes of the 71% of interruptions, it shows how complicated vegetation managing has become with the influence of extreme weather in the equation. That's why relying on legacy vegetation management and asset inspection approaches such as fixed cycle surveys, rotational trimming, and ground crew inspections aren't having much effect on reducing outages. Even those who have added drones, helicopters, and other aerial platforms aren't seeing improvement in outage numbers.

Things improve somewhat for those taking the leap to vegetation management platforms utilizing LiDAR (light detection and ranging) and photogrammetry. Satellite technology provide continuous surveying of a utility's territory with multispectral, and hyperspectral technologies. Multispectral and hyperspectral imaging gather data from multiple bands across the electromagnetic spectrum – most of which cannot be seen by the human eye.

What makes this noteworthy is the data cube these applications provide to 21st century vegetation management platforms. With this technology, the platform can tell the health of the plant life and type of tree found along any ROW and adjacent terrain. That is why it's an important advantage of all the state-of-the-art surveying and asset inspection technologies available to the vegetation managers and their teams, but there are drawbacks.

These cutting-edge applications generate terabytes of this bigger-data, which must be analyzed, or important information can be missed. That is why integrating vegetation management platforms with autonomous AI is important. They are designed to sift through all data sources and identify risks before they become dangerous. When that is combined with digital twin technology it is seen as being transformational.

Without going to deeply, digital twins are a virtual representation of a physical asset. This representation is a model and utilities have used LiDAR for years to develop detailed digital models of their transmission lines and distribution circuits. At the same time, all of the plant life on and to the sides of the ROWs have been developed too. Spectrum imaging has taken the detail to the tree level identifying the species, growth patterns, soil conditions. and more.

With all of this existing data, combining digital twin virtual technology with vegetation management and enhanced AI applications is the next logical step in the process. The digital twin shows everything power line modeling is famous for plus the plant life under, along, and beside the ROWs. This version of the digital twin systems includes the environment with the power line, and it can be linked with real-time weather conditions. The AI enhanced digital twin can measure plant growth, soil moisture, and tree health. It also classifies a tree's threat level (i.e., low, medium, and high) based on a variety of power line characteristics. Taking it a step further, platforms can run simulations based on predicted weather patterns and a range of power line loading criteria and predict trouble spots many months in advance. This risk analysis can identify problem areas with sufficient time for the utility to take action and remove the outage hazards.

This may sound like science fiction, but the technology exists, and it's used by utilities today, but not all of the applications offered are equal. It's one of those applications that are called an emerging technology and it's important to do your homework when specifying the platform.

The abilities of these systems vary due to their cost, how they are expected to be used, and how they are specified. Some are what is called an "end-to-end intelligent suite" that include everything from automated hazard identification to hiring trimmers to remove those trouble-trees. Some systems may specialize in data analysis, while others fall somewhere in the middle. Last March "Charging Ahead" talked about how change is exponential, which tends to make everyone extremely uncomfortable. Vegetation management technologies enhanced with autonomous AI definitely fit into that category, but it has a lot going for it when it comes to reducing power outages! TDW

CALIFORNIA APPROVES BILLIONS IN NEW TRANSMISSION INVESTMENT

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The California Independent System Operator, the non-profit entity overseeing the state's bulk electric power system and electricity market for its member utilities, gave the thumbs up to a plan that will invest $7.3 billion over the next decade or so into power grid improvements.

The transmission plan earmarks 45 projects for system expansions and upgrades, and was pared down from an earlier version of the plan that called for $9.3 billion and 46 projects, according the ISO.

These investments will support some 40 GW of new resource development, most of which will be built in California. The California Energy Commission and the California Public Utilities Commission agreed that this plan was in the public interest.

Specific transmission projects provided for by the plan include:

- A new 500 kV transmission line running west from the Arizona border into southern Imperial County, new 500 kV transmission lines angling up from southern Imperial County to northern San Diego and extending into the southern LA Basin, and upgrades to the existing 500 kV and 230 kV lines along the Interstate 10 (I-10) corridor. Together, these upgrades provide access to east Riverside County, Imperial County and Arizona solar generation, Imperial Valley geothermal, and New Mexico wind generation;
- Upgrades to the Lugo–Victor–Kramer 230 kV transmission system to access north of Lugo solar resources; and
- A host of smaller upgrades improving access to other smaller resource zones.
- The ISO also found a need for a new 500 kV transmission line from southeastern Nevada to the eastern edge of the LA Basin and rebuilding of existing southeastern Nevada 230 kV transmission inside the ISO to 500 kV, providing access for Eldorado and Pisgah area solar generation, southeastern Nevada solar and geothermal generation, and Wyoming and Idaho wind generation. In response to stakeholder input and comments, the ISO is evaluating a new alternative — the conversion of the existing Mead-Adelanto 500 kV transmission line from AC to DC operation – before making a final recommendation. Once the ISO has completed its analysis, a recommendation will be brought to the board of governors either as an extension of this year's plan or in the next planning cycle.

Projects identified in the plan will enable critical resource development, including:

- Over 17 GW of solar generation distributed across the state in solar development regions that include the Westlands area in the Central Valley, Tehachapi, the Kramer area in San Bernardino County, Riverside County, and also in southern Nevada and western Arizona;
- Over 3.5 GW of in-state wind generation in existing wind development regions, including Tehachapi;
- Over 1 GW of geothermal development, primarily in California's Imperial Valley and in southern Nevada;
- Access for battery storage projects co-located across the state with renewable generation projects, as well as stand-alone storage located closer to major load centers in the LA Basin, greater Bay Area, and San Diego.
- The import of over 4.5 GW of out-of-state wind generation from Idaho, Wyoming and New Mexico by enhancing corridors from the ISO border in southeastern Nevada and from western Arizona into California load centers.

California's energy future will be a top item of discussion at the T&D World Conference and Exhibition 2023, Sept. 12-14 at the SAFE Credit Union Convention Center. To learn more about the California energy market and the future of electricity delivery around the world from high-level utility speakers, register for T&D World. If you register by Aug. 11, 2023 you can receive a $100 early bird discount on your registration package. ■ —*Jeff Postelwait*

NRECA: RELIABILITY ASSESSMENT A 'DIRE WARNING' ABOUT POWER GRID CAPABILITIES

mechichi / iStock / Getty Images Plus

National Rural Electric Cooperative Association CEO Jim Matheson called for federal energy policies to be more in tune with the problems facing utilities today, including challenges to power grid reliability.

The statement was in reply to the North American Electric Reliability Corporation's summer 2023 reliability assessment, which found that two-thirds of North America may be affected by electricity supply shortages due to heat waves.

"This report is an especially dire warning that America's ability to keep the lights on has been jeopardized," Matheson said. "That's unacceptable. The decisions we make today determine whether utilities across the nation have the resources to power the American economy tomorrow. Federal policies must recognize the compromised reliability reality facing the nation before it's too late.

NERC's assessment found that while resources are adequate for normal summer peak demand, demand may be higher than normal in seven areas, including the U.S. West, the Southwest Power Pool, the Electricity Reliability Council of Texas, the Mid-continent Independent System Operator, the SERC Central, New England Independent System Operator and Ontario.

"American families and businesses expect the lights to stay on at a cost they can afford. But that's no longer a guarantee. Nine states saw rolling black-outs last December as the demand for electricity exceeded available supply. And proposals like last week's EPA power plant rule will greatly compound the problem. Absent a major shift in state and federal energy policy, this is the reality we will face for years to come. It's vital that policymakers work to prioritize reliability in every energy policy discussion."

NRECA identified several causes for reliable power delivery at the moment, including higher demand due to electrification of transportation and housing; falling supply due to plant retirements; permitting delays for new transmission and other grid infrastructure; natural gas supply issues; and supply chain challenges.

Earlier in May, commissioners with the Federal Energy Regulatory Commission testified to the Senate that the U.S. may be heading for a "catastrophic" reliability problem. ■ —*Jeff Postelwait*

QUANTA CEO: ENERGY TRANSITION INVESTMENTS NEED 'MORE COLLABORATIVE ENVIRONMENT'

Federal and state energy agencies should be more collaborative and strategic in their decisions to help the United States avoid serious stumbles during the energy transition, the CEO of infrastructure services provider Quanta Services Inc. told investors June 1.

Speaking at a conference hosted by research firm Bernstein, Quanta President and CEO Earl 'Duke' Austin Jr. said he'd like to see a broad long-term plan that helps utilities make the shift from today's energy system to a carbon-free environment in which electric vehicles are a major consumer of power. A shortfall of such long-term thinking, he said, is the biggest bottleneck facing the sector.

Courtesy of Quanta Services.

"Federal policy and state policy [are] disconnected a bit from the standpoint of how we're pushing incentives for builds," Austin said. "There needs to be a more collaborative environment [for] everything from permitting down to funding."

With utilities and other companies planning to spend hundreds of billions of dollars to expand and strengthen their networks—PG&E Corp., a Quanta customer, last week sketched out a plan that would have invest an average of $13 billion annually from 2028 to 2032 in California—rate payers across the country are being asked to fund a wide range of projects. But Austin said companies and regulators can do a better job communicating how rate payers' money translates into improvements.

"The regulator is going to be concerned about what does [a large capital spending plan] do to the bill -- that day, that year -- instead of looking at this more in a long-term nature," he said. "I think those hangups will be out there and you'll see some political strife on that."

Quanta, which in late 2021 acquired Blattner Holding Co., stands to be a big beneficiary of energy and other infrastructure investments for years to come: Austin and CFO Derrick Jensen last year said organic growth alone stood to add $9 billion to the company's top line by 2027 and Austin on June 1 said his team has the chance to grow profits per share at more than 15% per year in the near future. But he also noted that strains are already showing in the grid's ability to handle the mass adoption of EVs, pointing to several days last year when some drivers were asked not to charge their cars.

Parts of the infrastructure equipment supply chain also still need to improve, Austin added, although he's optimistic that will happen in the coming year. But poles and transformers remain a problem, with wait times still regularly reaching two years. (See also: 'No Easy Answers: Transformer Supply Crisis Deepens' from February.)

"It's not terrible but it's still an issue," Austin said. "If you're a smaller utility or smaller developer trying to build, it's very difficult."

Shares of Quanta (Ticker: PWR) were changing hands at nearly $180 on June, up more than 2% on the day. Over the past six months, they have climbed more than 15%, growing the company's market capitalization to more than $26 billion. ■ — *Geert De Lombaerde*

MINNESOTA POWER PLANS UPGRADES TO HVDC TRANSMISSION SYSTEM

lupm / iStock / Getty Images Plus

Minnesota Power, a division of ALLETE, has unveiled its plans to upgrade the high-voltage, direct-current (HVDC) transmission system that transports renewable wind energy from the Bison Wind Energy Center in North Dakota to customers in Minnesota.

To accomplish this, Minnesota Power intends to submit a Certificate of Need and Route Permit on June 1 to the Minnesota Public Utilities Commission. The purpose is to replace outdated critical infrastructure and modernize the terminal stations along the 465-mile HVDC transmission line spanning from Center, North Dakota, to Hermantown, Minnesota.

"Investing in transmission and replacing aging infrastructure with modern technology are critical to strengthening the reliability and resiliency of the grid in the Upper Midwest—especially as we experience more frequent extreme weather events and our energy supply continues to evolve," said Julie Pierce, vice president Minnesota Power Strategy and Planning. "Maintaining and enhancing the reliable delivery of essential energy is a critical component of Minnesota Power's EnergyForward strategy as we prepare to meet the state of Minnesota's accelerated standard of delivering carbon-free energy by 2040."

In Minnesota, the HVDC Modernization Project involves the replacement of aging converter facilities at the Arrowhead Substation in Hermantown with new structures and advanced electrical infrastructure near the existing terminal. Additionally, the project includes the construction of three short transmission lines, each less than a mile long, on the site to connect the new converter station to the existing electric system. Similar upgrades are planned for the converter facilities at the Square Butte East Substation in Center, North Dakota.

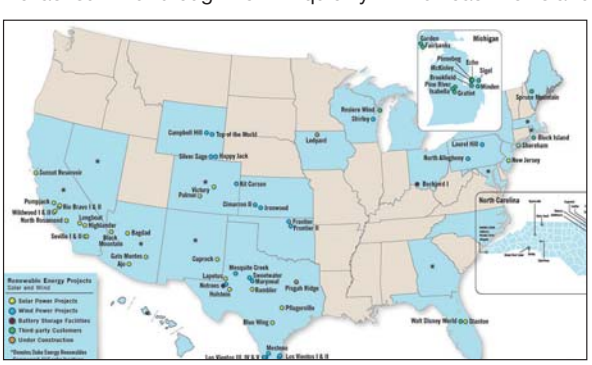
HVDC modernization project benefits include:

- Improves transmission system reliability.
- Minnesota Power seeks funding to minimize rate impacts, securing $15 million in state funding. Preferred supplier agreement with Siemens Energy ensures timely project delivery.
- Permits from North Dakota Public Service Commission will be sought for HVDC facility modifications.
- Enhances system resiliency with bi-directional line capability for flexible energy flow.
- Expands operating capacity for future energy transfers in the Upper Midwest.
- Replaces aging critical infrastructure.
- Pending regulatory approvals, construction could start in 2024 with completion expected between 2028 and 2030.
- Estimated project cost: $800 million to $900 million.
- Actively engages with landowners, stakeholders, and the public for feedback during the regulatory review process. ■

BROOKFIELD TO BUY DUKE UTILITY-SCALE RENEWABLES PORTFOLIO

Duke Energy Corp. executives have signed a deal to sell their utility-scale unregulated renewable energy portfolio to Brookfield Renewable for nearly $1.1 billion in net proceeds.

The announcement checks a big box for Chair, President and CEO Lynn Good and her team, who last summer brought to market their renewables group—the company's distributed energy business, valued on Duke's books at $450 million, also is close to being sold—to lighten Duke's debts and focus on investments in its regulated businesses. But, in line with other recent renewables transactions involving Eversource Energy and American Electric Power, the deal with Brookfield also calls for Duke to take an $800 million impairment charge to go with the charge of more than $1 billion it took last year.



Courtesy of Duke Energy.

"Brookfield has the resources to support the continued growth and success of the Commercial Renewables' portfolio," Good said in a statement. "This sale is an important step in our transition into a purely regulated company with significant grid and clean energy investment plans that will deliver benefits to our customers and stakeholders."

The agreement with Brookfield, which has a total enterprise value of about $2.8 billion, comprises more than 3.4 GW of solar, wind and battery storage assets as well as more than 2 GW under construction. Brookfield will pay Duke in two equal payments, the first at closing later this year and the second 18 months later.

Brookfield executives expect their planned acquisition to quickly lift their cash flows and see opportunities both to repower turbines and to sign new contracts with large commercial buyers.

"We are also adding to our pipeline of renewable development projects, solidifying our position as one of the largest renewable energy businesses in the U.S. with almost 90,000 megawatts of operating and development assets," said CEO Connor Teskey.

Brookfield Renewable (Ticker: BEP) controls one of the largest publicly traded clean-energy portfolios: Across North America, South America, Europe and Asia, it owns about 31,600 MW of installed capacity and has in development about 131,900 MW of renewables as well as other assets.

Shares of Duke (Ticker: DUK) closed June 12 at $91.39, down slightly on the day. They have lost about 10% of their value over the past six months, trimming the company's market capitalization to roughly $70 billion. ■

— Geert De Lombaerde

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FirstEnergy Syncs Up ADMS

Adoption of this integrated ADMS platform has resulted in enhanced DER management, improved reliability and customer service, and reduced costs across operations.

By **KEVIN HAWRYLAK**, FirstEnergy, and **SAMEER KALRA**, Oracle Energy and Water

What if front-line field personnel in the midst of storm recovery could summon real-time operations data in the palm of their hand, gaining the same awareness of outage isolation and switching information as the control room? This is not a hypothetical.

Increasing demands on power grids require far more nimble responsiveness, problem pinpointing, and accurate forecasting than ever before to maintain reliability. This creates everything-all-at-once scenarios with higher frequencies.

The Front-line Challenge

The complexity of today's grid requires real-time awareness on a greater granular level than ever before. That means matching and scheduling power for customers against clean but more intermittent generation from wind and solar power, and adjusting to the impacts of EVs charging, smart thermostats, and other devices on the grid. Grid operators are on the front lines of the energy transition and climate change.

For FirstEnergy, its challenges were tenfold, literally. The company wanted to migrate legacy grid management systems for 10 utility operating companies serving 6.1 million customers in six states to adopt the Oracle Utilities Network Management System, Oracle's Advanced Distribution Management System (ADMS) offering.

This four-year mega project, known internally at FirstEnergy as "aDAPT" (Distribution Applications Powering Tomorrow), went live in August 2022, bringing 269,000 miles of distribution lines under a singular system to manage outage restoration, advanced applications (Distribution Automation (DA) and Volt/Var Optimization (VVO) – Ohio operating companies only) and more. To our knowledge, this project comprising a single ADMS across multiple service territories is the most significant ADMS adoption by a large utility corporation in terms of cost, schedule, and functionality.

"Simply put, we needed our system to let us easily see and predict how power is moving on an increasingly complicated and layered grid, while also ensuring everyone across service territories are operating from the same place in terms of process, software, and shared purpose," said Ted Allan, Director, ADMS/GIS Project, FirstEnergy. "We also wanted to implement a new fully integrated system that would be foundational for additional smart grid investment."

The forerunner for the new system deployed by FirstEnergy was the original ADMS developed in 2007 by Oracle. The architecture of ADMS has the capability to expand to handle additional demands, from the proliferation of a wide variety of DERs — such as rooftop solar, EVs, and battery storage — to changing weather patterns with extreme weather events. These platforms aid in automated outage response and help optimize performance of utility distribution grids utilizing a common model and operator user interface.

Streamlining and Efficiencies

The FirstEnergy project shows how a system can be built to provide real-time awareness across multiple streams of data, from measuring customer load and detecting outages, to forecasting weather and power price effects on demand. This, combined with predictive modeling, allows operators to be deliberately

Advanced Distribution Management System helps manage large scale events streamlining work practices and supporting efficiencies. Photo by FirstEnergy.

responsive and proactive instead of only being reactive. The resulting ADMS functions on a single software platform, serving as both a digital twin and a nerve center that can unify complex operations, centralize decision-making, and bring consistency across the operating companies.

What does this look like in practice? ADMS helps manage large scale events streamlining work practices and supporting efficiencies.

In the control room, operators can see all essential data, e.g. real-time power flow and network model updates, via a "single pane of glass." This helps simplify decision-making, and thus helps enhance safety, reliability, restoration, and system planning. Visibility and management of the overall network extends beyond the control room:

- On the ground, line workers can clearly see what's happening with Oracle's Operational Mobile Application (OMA), which enables them to update outages directly from their mobile device.
- In district offices and other remote locations, FirstEnergy staff can easily connect to a browser-based version of the ADMS – called Flex Operations – to help manage outages, crews, and switching.

Heightened Awareness

A key objective was to give control room operators and field workers the same situational awareness.

The Oracle Utilities NMS Flex Operations (FlexOps) application extends outage management and crew dispatch capabilities beyond the control room, enabling hundreds of additional users to quickly and securely log on to help manage outage restoration activities. FlexOps includes outage and crews lists, and an interactive network viewer that displays conductor highlights,

In the control room, operators can see all essential data, e.g. real-time power flow and network model updates, via a "single pane of glass." This helps simplify decision-making, and thus helps enhance safety, reliability, restoration, and system planning. In district offices and other remote locations, FirstEnergy staff can easily connect to a browser-based version of the ADMS – called Flex Operations – to help manage outages, crews and switching. Photos by FirstEnergy.

phases, text annotations, map backdrops, and other real-time network information similar to the core ADMS.

Field crews can receive outage restoration, damage response, and hazard assessment tasks on their mobile devices, and then can provide updates directly, without waiting to relay information back to the control room. The new system also lets operators ping AMI meters to quickly see if any downstream nested outages remain, avoiding return trips by restoration crews and, hopefully, increasing customer satisfaction.

So the traditional methods of managing outage dispatch and transcribing outage updates from within the control room are evolving. Control room staff are now supported by remote users and mobile-enabled crews, removing workflow bottlenecks and communication bottlenecks. This shortens the outage impact while helping the utilities keep utility customers informed and safe.

To help enhance safety and efficiencies in storm restoration, Oracle Utilities NMS includes automated, "self-healing" support with a Fault Location, Isolation, Service Restoration (FLISR) Application that enables utilities to sectionalize outage impact, reduce outage duration, and enhance reliability.

The new ADMS system was recently put to the test with a series of severe thunderstorms in late March and early April causing outages for customers in Ohio, Pennsylvania, and neighboring

In Ohio, FirstEnergy contractors perform work at height on the utility's Grid Mod I set of system upgrades. Photo by FirstEnergy.

American Transmission Systems, Inc. (ATSI), a subsidiary of FirstEnergy Corp., works on upgrades to 13 miles of a high-voltage transmission line in Carroll and Columbiana counties in Ohio. Upgrading this segment was the first phase of a larger 64-mile transmission line project. Photo by FirstEnergy.

parts of FirstEnergy service territories. After the first wave of storms, Oracle and FirstEnergy undertook an after-action review to see how to improve the pace of outages restoration, and then enhanced some of the configurations for system monitoring alarms as well as the mobile application. As a result, when the second wave of storms rolled in, the Oracle ADMS system showed processing improvements to allow personnel to the east of the affected areas to assist in their colleagues' territories to optimize the dispatch of mutual aid crews for outage restorations.

"The enhancements put more visibility on the outages so we could ensure efficient response," Allan said. "This system is truly flexible in adapting to our needs and adjusting on the fly with improvements."

Managing DER Behavior with Machine Learning

Machine learning helps utilities better monitor, control and optimize behind-the-meter devices, including taking control during peak demand periods to keep the grid stabilized and conserve energy.

Automated voltage regulators and line capacitor banks were installed on select circuits within FirstEnergy's Ohio operating companies to help ensure safe, constant voltage levels along power lines on extremely cold or hot days that create high demand for electricity. In addition to preventing voltage issues for customers, the NMS could potentially help provide energy savings by evenly distributing electricity, through control of these devices via the NMS's VVO application, to allow all customers served by a single power line to receive the same flow of safe, reliable power.

These operational enhancements, in turn, help utilities provide better options for customers. For instance, a utility's increased visibility into real-time hourly and peak load data can enable the marketplace to develop customer rate-choice programs and utilities can work with customers to more easily add new, grid-integrated devices.

Mixing Old and New

All of these enhancements need to seamlessly integrate with the utilities' existing system architecture.

When FirstEnergy embarked on the optimal way to deploy an ADMS, it wanted to leverage as many existing systems investments as possible, including the existing backbone of Supervisory Control and Data Acquisition (SCADA). Instead, it sought an ADMS that would work across its operations and draw on multiple existing strengths.

There also was no need to reinvent the wheel or strand assets. Instead, Oracle Utilities Live Energy Connect provided a scalable, technology-agnostic integration with an OT-centric middleware platform that supports all major protocols for utilities' existing SCADA systems. The overall project also ensures cybersecurity for integrated technologies under one NERC-CIP compliant architecture with IP-based network compatibility.

"We developed a much smarter grid and brought our operating companies onto the same page, virtually onto the same screen," Allan added. "The project helped us compose an expanded architecture that maintains key assets, such as SCADA, and added tools for a new system that is greater than the sum of its parts. This creates an orchestration of grid operations that is responsive, efficient, optimized and secure."

The project retained the existing strengths and built new functions to handle the various new dynamics of the modern grid. It also provides efficiencies by using a single platform to replace multiple systems and procedures.

"Together, we were able to unravel the Gordian knot from integrating a series of acquisitions, each bringing varying systems and significant unnecessary complexities. We created a new universal framework that better serves customers of multiple utilities across a vast swath of the country," said Brad Harkavy, vice president of product, Oracle Energy and Water. "This shared system literally brings calm to the storm, giving crews and operators from

different service areas the ability to jump in and seamlessly and safely support each other when every minute counts."

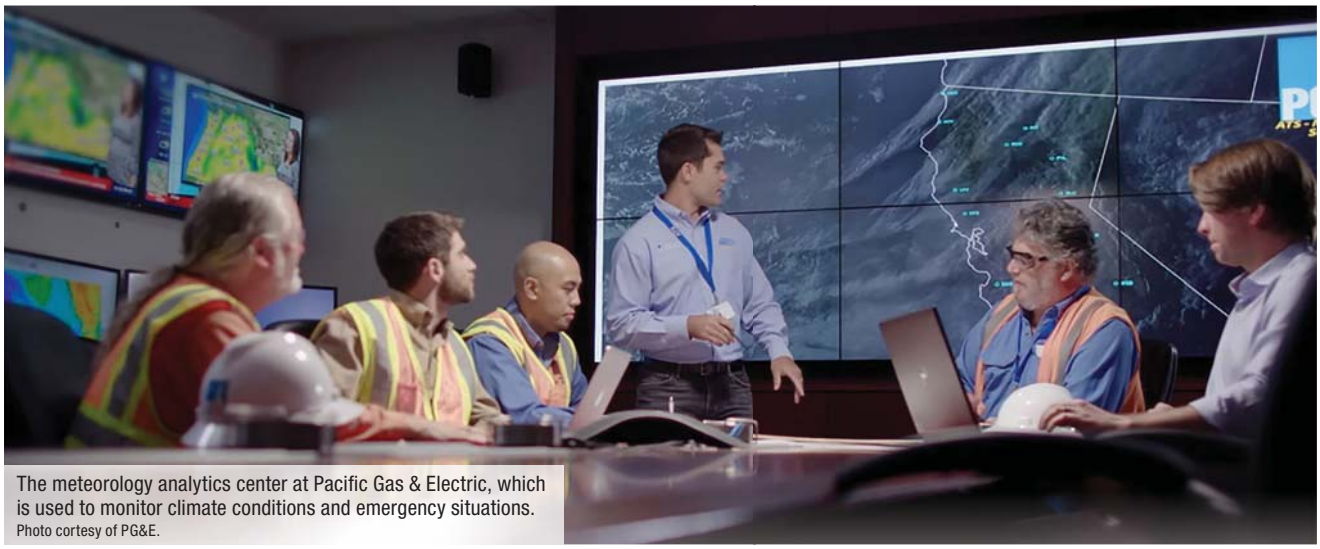
FirstEnergy reports that its adoption of this integrated ADMS platform has resulted in DER visibility, improved reliability and customer service, and reduced costs across operations. Importantly, this was not an off-the-shelf solution. Oracle and FirstEnergy collaborated through the course of the project on enhancements to create new capabilities to the ADMS-licensed product Oracle provides for other utilities.

"This ADMS platform provides better control over surging DERs and grid devices, to more accurate confirmation of timely restoration efforts, the grid can evolve apace with, and even ahead of, new system demands," Harkavy said. "By our team embedding with utilities to fully grasp their capabilities and needs, we can more effectively work together to enable dramatic improvements in system stability, efficiency, and safety while driving down operating costs with streamlined solutions." TDW

Visibility and management of the overall network extends beyond the control room. Line workers can see what's happening with the app. Photo by FirstEnergy.

KEVIN HAWRYLAK (*khawrylak@firstenergycorp.com*) is manager and business unit owner of FirstEnergy's ADMS systems. With FirstEnergy for almost 20 years, he began his career as a design engineer in the transmission engineering department. He rotated through various engineering departments, including substation maintenance, transmission planning and protection as well as distribution planning and protection. Hawrylak worked in the Cleveland Electric Illuminating Co.'s distribution control center as an engineer, supervisor and manger for eight years. He managed various overhead lines departments for almost four years. He most recently led the ADMS portion of FirstEnergy's four-year ADMS/GIS implementation project. He attended The University of Toledo, where he obtained his BSEE degree.

SAMEER KALRA (*Sameer.kalra@oracle.com*) has been working to accelerate the clean energy transition for more than 15 years. In his current role as director of operational technology products at Oracle Energy and Water, he is responsible for building solutions leading to decarbonization and grid transformation. He joined the company after spending nearly 10 years with Pacific Gas and Electric Co. (PG&E) in various roles responsible for product and digital strategy, technology innovation, and smart grid and technology integration. Prior to PG&E, he held positions with Infosys, SmartSynch (Itron) and Silver Springs Networks. Kalra regularly presents at industry events on topics related to distributed energy resource management and digital strategies for the grid.



The meteorology analytics center at Pacific Gas & Electric, which is used to monitor climate conditions and emergency situations. Photo cortesy of PG&E.

Fighting Fire with Technology

PG&E and partners have worked to develop and refine a machine learning fire-potential index model.

By **SCOTT STRENFEL**, PG&E

Only in the last two decades has the word "wildfire" become synonymous with other catastrophic weather events, such as hurricanes or EF5 tornadoes. Multiple studies have found that climate change has led to an increase in wildfire season length, frequency, intensity and burned area. In California, historically, utility infrastructure has been responsible for less than 10% of reported wildfires, but with the changing weather and other factors, fires attributed to power lines from 2015 to 2020 made up nearly half of the most destructive fires in California's history.

This alarming trend has electric utilities and distribution networks in California searching for better ways to prevent and prepare for future catastrophic events. Pacific Gas and Electric Co. (PG&E) is taking it one step further. In California and elsewhere, having a wildfire mitigation plan is more than just being prepared to manage wildfires.

PG&E is focused on not only preventing catastrophic fires in its service territory but also on sharing tools, technologies and lessons learned to help end utility-caused catastrophic fires. This approach is rooted in one of the company's stands that "catastrophic wildfires shall stop."

The fire science and wildfire mitigation team at PG&E are working with partners DTN, Technosylva, Atmospheric Data Solutions, Sonoma Technology Inc. and San Jose State University to develop and refine a machine learning fire potential index (FPI) model that predicts the probability a wildfire will spread into a large or catastrophic fire — even before a fire ignites. With the right insights, the team will be able to make operational decisions about the necessary actions needed to prevent a fire from ever occurring.

Scott Strenfel, PG&E chief meteorologist, leads a discussion. Photo cortesy of PG&E.

How FPI Works

For years, wildfire response crews and utilities in fire-prone areas have vigilantly monitored environmental and weather factors to prepare and respond to changing conditions, but extreme fire behavior — fueled by long-term drought, warming temperatures and drier fuels because of climate change — have made forecasting wildfires and adjusting grid operations a critical task to mitigate risk. The FPI

model represents the next evolution of fire prediction for PG&E. It deploys machine learning algorithms across more than 30 years of historical data sets of weather, fuels and historical fire occurrence every hour to determine the probability that fires will grow large, given current and forecast data.

The FPI model features include the foundation of the fire behavior triangle (weather, fuels and topography) and novel features such as wind-terrain alignment and detailed fuel moisture by species and type. PG&E uses the FPI to modify operations, from adjusting work procedures for field personnel and the sensitivity of automatic devices to executing a public safety power shutoff, depending on the level of risk.

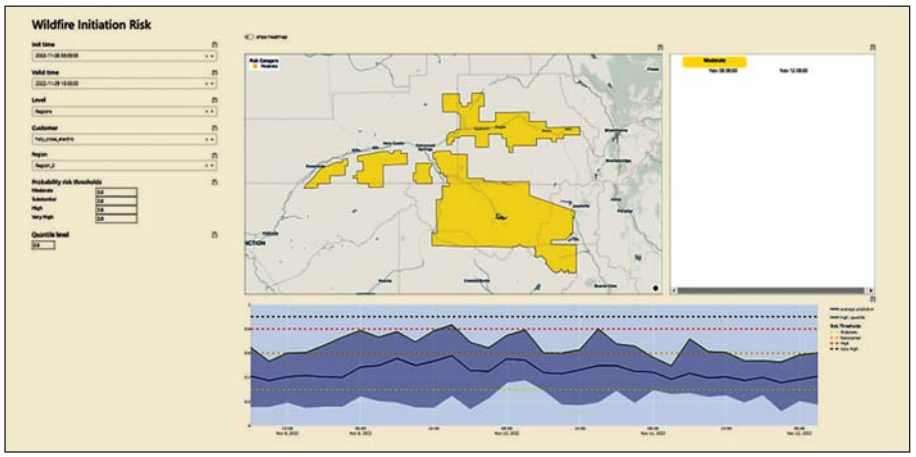
"Historically, utilities had limited visibility to the actual wildfire risk on any given day and given hour," said Nic Wilson, DTN product manager for weather risk. "With machine learning models and advanced analytics, utilities can take insights and decision-making further to reduce the risk of catastrophic fires."

The development of FPI started in 2014, became operational in 2015, and continues to evolve as additional findings and data sets are discovered and developed. Finding the right combination of data sets and identifying causation proved to be challenging in earlier model developments.

A pivotal piece of the newer version was incorporating a 30-plus year data set of historical weather data provided by DTN, a global data, analytics and technology company. The FPI model would not be able to exist without this foundational data source that feeds into other models and the machine learning model.

PG&E weather station installed on Mt. Diablo in the East Bay Area. Inset map shows PG&E's weather station coverage of ~1500 weather stations.

PG&E also works with the other innovation partners to incorporate additional critical data sets within the FPI model, including dead fuel moisture — which is derived on an hourly basis and

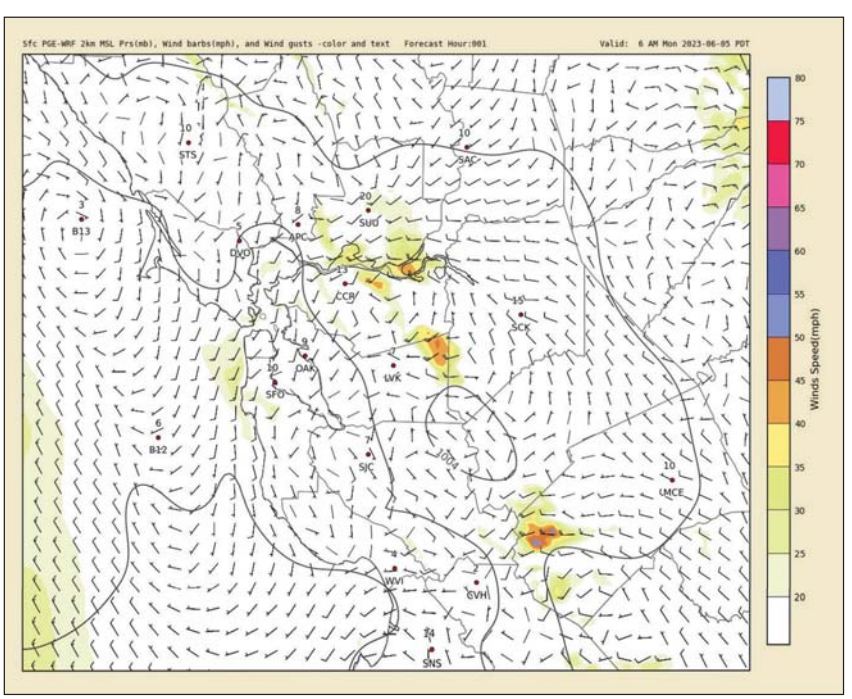


Example of DTN wildfire initiation risk prediction model prototype, which leverages PG&E's Fire Prediction Index Learning, to predict the probability of a spark growing into a wildfire less than 500 acres in size anywhere in the world.

fluctuates based on temperature — humidity solar radiation and live fuel moisture data sets for multiple plant species in California.

Terrain features and dynamic wind-terrain alignment also are important factors, computed each hour as part of the historical and forecast data to surface key planning insights. For example, the FPI model shows higher risk for winds perpendicular to terrain features compared to parallel. This perpendicular alignment occurs during Diablo and Santa Ana wind events in California and can lead to the downslope acceleration of winds.

The FPI model also is trained on historical fire occurrence data sets enhanced with fire detections from polar and geosynchronous satellites to provide sub-daily fire growth intelligence. When combined with hourly weather and fuel data sets, this enables the FPI model to learn, down to an hourly resolution, why or why not a fire may have grown over a short time frame.



Forecasted wind gusts for the Bay Area from DTN's 2km WRF model, accessible from the San Jose State Wildfire Interdisciplinary Research Center.

The FPI model is refreshed multiple times per day, whenever new forecast data sets are available and received. Running and processing these massive high-resolution data sets multiple times per day requires immense computing power and new modeling techniques to deliver timely data.

Fortunately, DTN was already pioneering a faster global forecast delivery model than is the industry standard using high-performing cloud infrastructure, so the team knew that it could integrate this data quickly into its own cloud computing environments.

Other Variables

PG&E and the FPI innovation partners continue to evaluate other variables that may add more skill, such as different types of live plant species, soil moisture and weather model features. These data sets also are being shared with leading scientists from San Jose State University's Wildfire Interdisciplinary Research Center (WIRC). WIRC continues to conduct active research and share results and findings with the community through peer-reviewed publications and directly with PG&E. These findings are then wrapped into new versions of the FPI model.

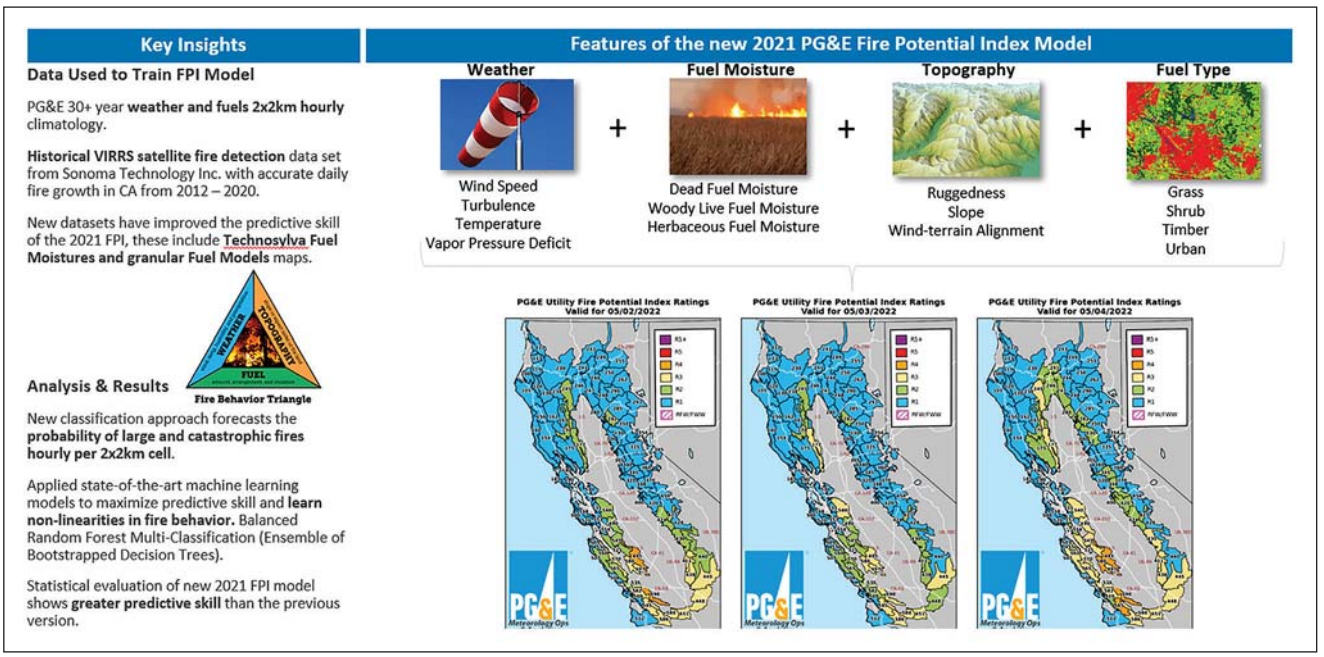
PG&E envisions not only continuous improvement of the existing model in years to come but also developing and refining new models that create automated and forward-looking forecasts of different hazards, such as outage models, flooding or combined extreme weather threats.

The plan is for utility and partners to continue working in tandem to bring the best minds, data sets and models to bear to achieve PG&E's company stand that catastrophic wildfires shall stop.

Informed Decisions

While the success of the FPI model increases the confidence of wildfire probability forecasting, the PG&E team is always seeking ways to improve how the utility responds to all weather-related threats. The team and its partners are focused on two main things: Continuing to shrink forecast error and translating risk into operational decisions to mitigate that risk.

That might mean defining new procedures and actions that need to happen when certain forecast levels or real-time conditions are met. At present, this ranges from ensuring actions in the field are taken to reduce the risk of fire events to applying more sensitive settings on automated devices and shutting off power proactively. During winter operations, this could include staffing



PGE Fire Potential Index with enhanced features and fire data with a new machine learning model.

for upcoming storm events, shifting resources internally and calling on mutual aid.

Blueprint For Prevention

PG&E maintains 125,000 miles (201,168 km) of power lines, about one-third of them in areas with a high fire threat, but wildfires are not unique to California. Fires also burned at a record pace in other parts of the country, such as Alaska, New Mexico, Texas, Oregon and Idaho, bringing the number of wildfires and acres burned in 2022 higher than the 10-year average.

While the FPI is modeled specifically for California wildfires, it is not just useful only in the PG&E service area. It is also replicable across different regions and even countries. The complete details of the FPI model are outlined in PG&E's wildfire mitigation plan. It may need to be scaled for different service areas and leverage different local data sets, but the blueprint is available for other utilities to leverage.

The PG&E team thought it important to share its work, as it was a community effort to improve wildfire mitigation. The group learned a tremendous amount from sister utilities in California who developed FPI models previously, and the feeling was it was important to pay it forward — in particular where doing so could help another utility create an operational model that can help them prevent a wildfire and save lives.

Many utilities have some data science expertise and computing resources available. With those resources, along with meteorologists, machine learning could be an option. If internal resources are not available to build a custom model, there are options available to partner with private weather companies like PG&E did with DTN and others.

"By working in cooperation with PG&E to identify the right input features and continuously refining the model, we are able to help them be successful, but our partnership will also help other utilities across the globe leverage machine learning and advanced analytics to develop their own version of a fire prevention model," said DTN's Wilson.

PG&E uses the FPI to modify operations.

As wildfires continue to increase around the world, utilities are seeking methods to prevent and prepare for extreme events. One utility in California, with the help of innovation partners, has added another tool for reducing wildfire risk by fighting fire with technology. For PG&E, the FPI model is a dynamic blueprint for wildfire prevention that delivers on its statement that "catastrophic fires will stop." TDW

SCOTT STRENFEL is a utility weather and fire weather expert and has been in a utility leadership role for a decade. He currently runs the Meteorology Operations and Fire Science teams at PG&E and is the Chief Meteorologist for emergency activations. Prior to PG&E, Scott worked at Sonoma Technology Inc., and researched the efficacy of satellite-based fire detection systems and modeled emissions from wildfires. Scott holds a B.S. and a M.S. in Meteorology and was one of the first graduates from the San Jose State Fire Weather Research Laboratory.

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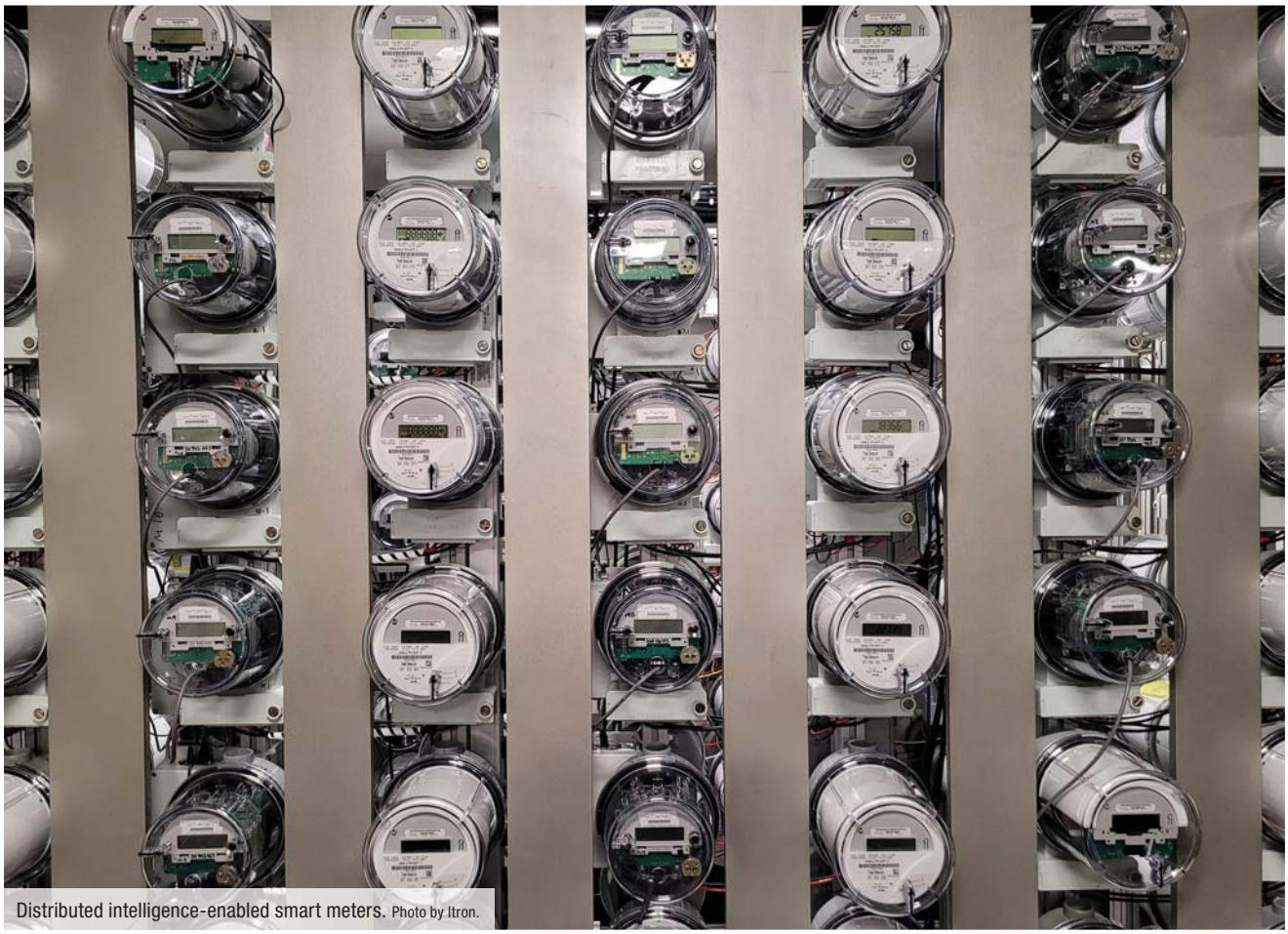


Distributed intelligence-enabled smart meters. Photo by Itron.

Getting Smart at the Edge

Commonwealth Edison is working to evolve distributed intelligence alongside advanced metering infrastructure.

By **NATALIE HAMMER**, ComEd, and **MEL GEHRS**, Itron

Distributed intelligence (DI) represents a new smart or active grid that can solve value-based use cases at the grid edge. Through open, secure applications, utilities can use edge-computing capabilities to gather data and insights around grid use and performance.

By relying on this DI enterprise application platform, utilities can obtain detailed data and a full picture of the grid in real time, maximizing the value of their advanced metering infrastructure (AMI) investments and looking towards next-generation capabilities. Before diving into next-generation AMI capabilities and what utilities aim to do with this technology, it is key to look at all the factors that influence AMI.

The Evolving Utility Mandate

There is a growing and evolving mandate for utilities to drive environmental and societal benefits with the technology they deploy to the field. Utilities are looking to continue making investments based on both internal and external factors. There are four specific principles a utility can use when thinking about what the future looks like:

- *Transforming the space.* This focuses on beneficial electrification (the replacing of direct fossil fuel use with electricity to reduce emissions and energy costs) and how to facilitate and enable adoption.
- *Investing in the future.* A cleaner, more distributed, and more secure energy future requires companies address basic system needs.
- *Uplifting communities.* Organizations need to drive equitable access to clean energy opportunities, infrastructure, and benefits.
- *Powering the policy.* To reach a clean energy future, utilities need to support policies for 100% clean energy.

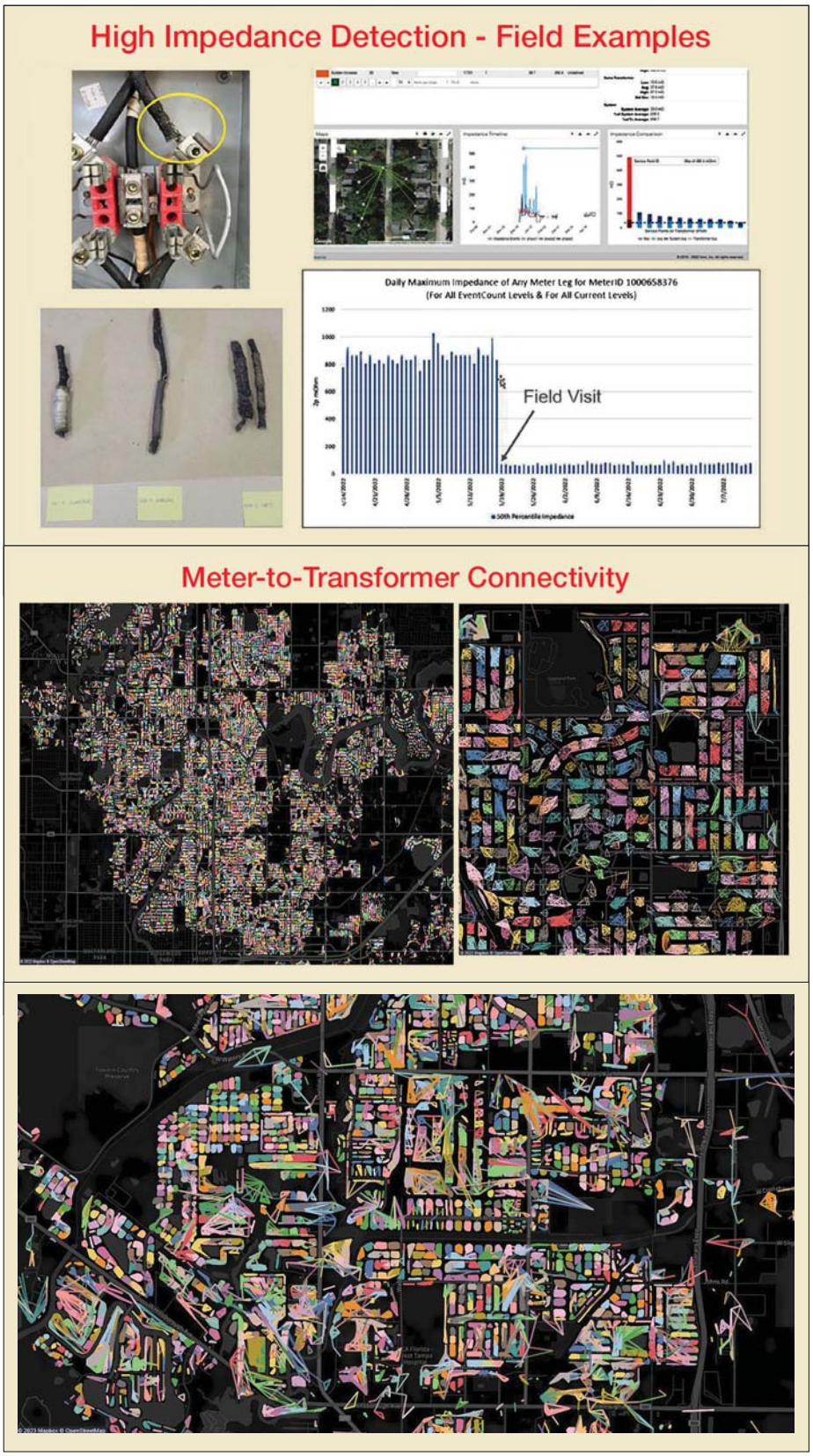
The external influences focus on the current environment when determining the impact on and from future AMI strategies, including:

- *Vendor capabilities.* What current AMI systems are influenced by, in terms of network and vendors.
- *Utility benchmarking.* Utilities across the United States are in various stages of AMI deployment. Some have not yet deployed AMI, some are in the process of deploying, some have installed a first-generation AMI, and some are jumping right into next-generation AMI. This impacts what technologies might be readily available from vendors.
- *Energy Infrastructure Modernization Act.* This 2011 legislation drove the original AMI adoption in Illinois and outlines the services a utility is expected to deliver through its investments.
- *Climate and Equitable Jobs Act.* This 2021 legislation sets targets for clean energy technologies, like electrical vehicles (EVs), beneficial electrification, and equitable clean energy in Illinois.
- *Regulatory guidance.* Regulatory entities investigate AMI deployments and hesitate to approve investment without sound business cases.
- *Infrastructure Investment and Jobs Act.* This 2021 legislation will drive investment in core infrastructure including power and grid-related programs, broadband, water infrastructure and low and zero-emission vehicles.

An example of high impedance; a bad hot leg connector. Photo by ComEd and Itron.

Next Generation Capability

With next-generation AMI, utilities can use edge computing, peer-to-peer communications, and data analytics to create new



A location awareness display. Photo by ComEd and Itron.

services for customers and ways to better run their businesses. However, over the years, the technology has rapidly evolved.

The typical level of AMI technology for utilities at this point is the original AMI 1.0. This introduced solid-state meters with greater resolution, two-way communication, and data management applications that greatly improved utility meter-to-cash operations—and opened the door to consumer engagement opportunities. This includes automated meter reads, the ability to remotely connect and disconnect from the meter, revenue protection, as well as automated, exact billing rather than estimating costs.

Field technology then advances to the next level with enhanced AMI. With the technology now installed, utilities and vendors continue to evolve and find new benefits to AMI installations. The rise of AI, edge computing, cloud services and more robust networking technologies — coupled with an "on demand" appetite for data and interactivity from consumers — has ushered in an era of digital transformation for utilities.

The capabilities of enhanced AMI include automatic outage detection, home energy reports, partnerships with other utilities via joint use infrastructure, customer segmentation, and distributed energy resource (DER) management where possible.

Leveraging the foundation from the AMI systems deployed throughout the 2010s, next-generation AMI (or AMI 2.0) is the next evolution of intelligent, connected utility systems that capitalizes on advanced communications, distributed intelligence, cloud services and data analytics to: better engage consumers, making them partners in the energy/water exchange; increase operational insight and visibility throughout the distribution system; deliver real-time data collection, analysis and action throughout the system — at the edge or back office as needed, or at any point in between; integrate new consumer-facing technologies like EVs and DERs; and ultimately better manage the flow of energy, water and essential services between the provider and end consumer. With a focus on peer-to-peer communications, the smart meters communicate with one another to enable things like advanced asset management

and predictive analytics. Much of this technology is currently being tested to evaluate ways to make the more advanced, grid edge AMI more beneficial for customers.

Evaluating with Smart Meters

Meters have gone through a major evolution. Utilities used to read meters once a month, which then shifted from reading every hour with AMI, to reading every 5-15 minutes. Now, next-generation residential meters are capable of being read 4,000 times per second, and polyphase meters can be read 32,000 times per second.

This advancement of meters leads to the generation of massive amounts of data collected every second. The amount of data can be overwhelming; what is the secret to dealing with it? Getting smart at the edge.

The way to do this is through a DI-enabled smart meter. This is a high-frequency sensor, analytic, and engine capable of acting on the grid edge. It has multiple channels for up to 32,000 measurements per second, can use data for value creation rather than just aggregation, can provision data to third parties or directly to the customer, and can correlate information to isolate the electrical location of grid events like power quality issues, safety problems, and outages.

These meters can utilize peer-to-peer communication to make informed decisions at the edge about what specific data should be shared back with the utility companies. This communication between meters allows for the isolation of the electrical location of grid events, alongside details about the actual problem. Evaluations of AMI can be conducted in laboratory settings to validate the results with meter boards that simulate the field.

High Impedance Detection

With high impedance detection, DI smart meters can determine impedance issues occurring from the transformer to the meter. Whether the issue is the state of the wire, splices or transformer, the distance between service drops, and the number of service drops, all can affect impedance. DI-enabled smart meters can daily determine the cumulative impedance of the meter base, wiring to and from the home and the transformer winding resistance. Using that impedance, the utility can detect high-resistance splices or faulty meter sockets or even a tree contact on the wire before an outage occurs.

In addition, using utility metadata about the meter and transformer locations, the utility can identify locations in the grid where the wire gauge is too small and/or the distance to the transformer is too long to support electric vehicles or solar panels at the premise. This is a huge advancement in the field, and one that has been heavily anticipated.

The Meter-to-Transformer Relationship

Using data from smart meters and peer-to-peer communications, utilities can map which meters are on each transformer. This has been a huge challenge in the past, and this capability is a game changer in the field. Every meter communicates with its neighboring meters on the same side of the transformer, this allows utilities to clean up and correct GIS records. In addition, along with meter ID, the neighboring meters can share the current voltage and loads at each premise ultimately determining the "real time" load on the transformer. Using this knowledge, the utility can determine hour by hour if any specific transformer is approaching an overload condition and proactively upgrade the transformer KVA rating before an overload condition occurs.

Predictive monitoring has been a perpetual problem for utilities. With next-gen AMI DI smart meters, utilities can identify cases of power quality issues or voltage notching, which happens when things like a car hitting a pole occur, there is a breakdown in a transformer or underground cable, or there are large variable frequency motors. By utilizing the data gathered by the meters, utilities can predict what issues may arise or what impacts an incident will have on the grid without involving guesswork. Teams can see if the problem lies with the grid or elsewhere improving overall grid reliability.

Next-generation AMI with DI has a lot of features to meet customer needs and move the grid management forward. Things like peer-to-peer communication, detecting high impedance, and location awareness are changing the utilities field and making it easier for companies to help their customers along the way. Technology continues to evolve, and as such, next-generation AMI will continue to evolve with it.

Evolving Meters

We have learned that although smart meters are a relatively new technology, they continue to evolve to meet the changing needs of customers as well as the power grid. Central to that evolution is the demand for more data at a customer premise, which drives the need for grid-edge applications, or distributed intelligence.

These applications can perform functions such as detecting high impedance conditions — indicative of potential faults on the distribution system — as well as location awareness, which will help utilities better monitor their facilities. Through these applications, the utility industry will be better equipped to meet the ever-changing needs of our customers and drive toward a future that includes higher penetration of EVs and DERs. TDW

NATALIE HAMMER is the senior manager AMI Strategy and Data Analytics for ComEd in Chicago. This includes overall responsibility for the strategic direction for Smart Meter Operations, developing advanced meter analytics and leveraging the AMI network to grow ComEd's smart cities applications and offerings. Hammer has over 13 years of utility experience ranging from engineering roles in distribution capacity planning and at a nuclear generating station to various operations roles in ComEd's transmission system control room. She has a Bachelor in Electrical Engineering and a Masters in Power Engineering, both from Illinois Institute of Technology.

MEL GEHRS is a technical sales engineer for Itron and for the past ten years, he has been working for Itron and is currently researching high-speed metrology and the appropriate math algorithms to build the next generation of DI agents. He brings a uniquely broad and deep skill set to the smart grid. Initially, Gehrs spent 30 years at ComEd/Exelon working in all areas of the utility as director of Strategic Planning. He has degrees in Nuclear and Electrical Engineering from Kansas State University.

Transmission Vegetation Management Transformation, Part II

In part two of this two-part article series, Duke Energy shares how its WorkPASS program has transformed the way it executes vegetation management work.

By **TIMOTHY J. "JACK" GARDNER**, Duke Energy Corp.

Duke Energy Corp. has a well-established and industry-recognized transmission vegetation management program that has enabled the utility to maintain a disciplined and consistent approach to managing vegetation along its transmission rights-of-way. Until recently, the utility's approach to managing vegetation along transmission lines relied on interval-based maintenance with specifications that prescribed what work needed to be performed.

As operational challenges and customer expectations evolved, Duke Energy determined this time-tested approach was no longer sustainable. The utility needed to transform the way it planned and executed work. As part of a comprehensive business transformation initiative, Duke Energy changed its operational strategy, organizational alignment, technology solutions and program documentation. Advanced data analytics and an open-minded approach to business processes led to two technology-related efforts to support the transformation of the utility's work practices: the implementation of an enterprise remote-sensing program (RSP) and development of a Work Planning, Analysis and Scheduling System (WorkPASS).

The RSP was featured in the first part of this two-part series in the June 2023 issue of T&D World. The second part of this article series focuses on WorkPASS.

WorkPASS Initiative

Once the RSP was established, the WorkPASS initiative kicked off to develop the tools, applications and predictive analytics necessary to manage the data, provide actionable execution information and support field mobile access to the data. WorkPASS consists of more than 20 task or workflow applications.

Each application and analytic solution falls within one of the following categories:

- Geospatial data management
- Data enrichment
- Risk predictions and optimization
- Work execution system.

Geospatial Foundation

Geospatial data management applications in WorkPASS provide a platform to manage and access RSP data and imagery deliverables. Across Duke Energy's four regions, 70 million to 100 million trees have been assessed for threats by the remote-sensing program and are managed in the WorkPASS geodatabase.

This database provides the foundation for all WorkPASS geospatial data and is integral to all data viewed, edited and updated through the applications.

Duke Energy has experienced numerous benefits using the work execution system applications to execute transmission vegetation management work.

Enriching The Data

Data enrichment provides analytics that enhance the RSP data with critical information for optimizing and executing the work. While the RSP data provides general insight into what the predicted work type will be (for example, mowing, herbicide, removal, trim), it is not sufficient to provide actionable information for execution.

WorkPASS uses data science to predict work units for each tree canopy. Once those units are identified, the next step is to associate predicted work-unit cost — or should-cost — information at a tree-canopy level. These enrichment steps are performed each year and involve millions of tree-canopy polygons.

Multiple mobile applications provide field users the ability to locate, field plan and mark corridor management work.

Risk Predictions And Optimization

Once the data enrichment process is finalized, the WorkPASS risk prediction analytics provide reliability risk values for fall-in threats along each transmission line. The analytics use a combination of variables to predict the reliability risk value and apply it at the tree-canopy polygon level. These values provide an input for annual work plan creation in the scenario planner tool. Additionally, the values are used by field personnel during work planning and marking.

To create an annual work plan, the scenario planning application uses tree-canopy reliability risk predictions and the enriched RSP data to evaluate numerous scenarios and to develop an optimized annual work plan for corridor management in each region. While the reliability risk predictions and RSP tree-canopy polygons can provide potential risk probability from threats for scenario planning, they also are important to understand and account for the impact or consequence if an outage were to occur.

To address this important variable, the Duke Energy Transmission Vegetation Management (TVM) organization created a line criticality index. This index is a weighted assessment of the consequences of an outage, which does not consider voltage as a factor. Once annual work plans are finalized, the scenario planning application optimizes the work plan for each region (multiyear planning also is supported) to include all the circuits and polygons that need to be addressed in the corridor management work plan.

Work Execution System

The WorkPASS work execution system provides solutions to plan and execute the corridor management and reactive management programs. Floor management is limited to field-planning tools in support of the interval-based program.

Once an annual work plan is published for corridor management in each region, a central hub called ROOTS allows users to assign, monitor and track work as it progresses through the work steps of planning, ready for work, assigned for work, ready for quality assurance (QA) and complete. In addition, ROOTS provides the ability to create an annual schedule for work plan completion and monitor actual progress against that plan.

Once work is assigned for planning in ROOTS, multiple mobile applications provide field users the ability to locate, field plan and mark corridor management work. These apps allow the field user to assess and change the predicted work units as site-specific and arboricultural conditions require. Upon completion of field work planning, ROOTS provides the ability to assign the work to a general foreperson, who has visibility of the assigned work in an app called LEAFOUT for execution and reporting of completed work. Completed work returns to ROOTS ready for QA, and once it is performed, the work can be either closed or sent back for rework as necessary.

Field planning and marking of reactive work findings is completed using the REACT field mobile app, with access to point cloud images. Following reactive work planning, the findings are available in ROOTS for work assignment and then in LEAFOUT for execution.

Duke Energy's floor management program continues to use an interval-based maintenance approach, and it is important to note the RSP-derived tree-canopy polygons do not represent all the work that should be handled under the floor program. Currently, the WorkPASS applications are only focused on supporting the field work planning tasks for floor management.

End-to-End Management

Innovative technological, analytical and application solutions were implemented through the RSP and WorkPASS initiatives. They have provided a solid foundation to continue to adapt, transform and expand well into the future. Together, they have produced meaningful long-term benefits. With these implementations complete, Duke Energy TVM has gained the ability to manage each of the vegetation management programs with an end-to-end approach, from the initial identification of conditions to the closing of work orders. These solutions also provide the capability to create annual work plans with actionable deliverables.

The technology solutions have provided significant advantages over manual processes, such as spreadsheets or nonintegrated, task-specific applications previously used to manage TVM programs. An end-to-end approach removes subjectivity

WorkPASS data will continue to provide information needed to improve each of the three TVM programs: corridor, floor and reactive management.

in assessing threats, provides common vegetation threat definitions across the enterprise, centralizes documentation and reduces human performance risk.

While many reporting tools and solutions still need to be developed, data associated with all identified corridor and reactive work is available for tracking and monitoring across the workflows within an individual program and across programs. The reactive management program is an example of improved visibility and tracking with a standardized and integrated solution. Prior to mid-2020, reactive finding identification and status tracking was a manual process managed by personnel responsible for areas within a region. This decentralized documentation limited access and visibility to the data by region and enterprise leadership. With the implementation of WorkPASS, the status of reactive findings from identification through execution is now tracked daily in a PowerBI report, with performance to the established expectations being reported on monthly TVM scorecards.

Probability Modeling

While transmission vegetation-related outages are rare and typically caused by off-rights-of-way (ROW) trees, they can have significant impact. To eliminate the impact, all identified fall-in threats from off-ROW trees would need to be removed or mitigated, which is neither practical nor possible. With the limited number of vegetation-related outages on transmission lines, using outage data to target specific circuits with a history of outage was not a viable option.

The WorkPASS initiative provided Duke Energy TVM the opportunity to explore options to proactively address, where possible, off-ROW threats. PREDICTIONS, a WorkPASS solution, employs risk modeling using a variety of datasets combined with RSP data to identify off-ROW tree threats most likely to cause a future outage. Using reliability risk probability modeling data during work planning is a way to explore opportunities to reduce the potential for outages. This approach is like a baseball coach stacking the lineup against a pitcher for the greatest opportunity for success.

Scenario Planning

With the transition to a condition-based approach for corridor management, simple prioritization methods used previously to adjust interval-based work plans were no longer sufficient. This led to another significant benefit from WorkPASS: the ability to consider different scenarios when creating annual corridor management work plans, and then optimizing and publishing those annual work plans.

One of the keys to increasing the value provided by scenario planning was separating vegetation threat probability of failure into two components: the integrity index (from on-ROW threats) and the reliability index (from off-ROW threats).

The scenario planning application provides flexibility to create an annual work plan that can be adjusted to meet constraints and objectives that include compliance adherence, risk reduction, cost control, specific threat targeting, reliability and integrity performance, and critical facilities. This functionality provides optimal annual work plans and valuable insights when mid-plan adjustments are needed.

Work Execution Benefits

Duke Energy has experienced numerous benefits using the work execution system applications to execute TVM work:

- Mobile access to data for field personnel
- Reduced need for spreadsheets
- Ability to create an annual schedule for the work plan
- Data access and workflow support for field work planning and marking
- Assignment of work to a general foreperson
- Web browser access to assigned work and for reporting completion of work.

Program Management Effectiveness

The greatest benefit may be the RSP and WorkPASS centralized database. The data provides insights into TVM programs that were not previously possible.

Access to reactive management program data has led to improvements already in the planning and execution of reactive work. The data will continue to provide information needed to improve each of the three TVM programs: corridor, floor and reactive management.

While the data supports improvement of processes, planning and execution for each of these three programs, the next step is to leverage the information to assess the effectiveness of TVM across all the programs. To that end, Duke Energy TVM has started leveraging the data to develop a TVM program effectiveness report. While still in the early stages of implementation, this report will focus on four areas of the program:

- Asset management (strategy)
- Program conditions
- Program reliability
- Work management (execution).

Three Crucial Elements

Duke Energy continues to enhance and transform its TVM program, and the ability to leverage technology will remain critical to the utility's transformation efforts. TVM's experience during implementation of the RSP and WorkPASS initiatives has demonstrated that fully leveraging technology requires more focus and planning than adopting an existing solution. To successfully leverage technology and derive the benefits, these three crucial elements must be considered:

- Strategic direction defines the technology and business requirements. While the drivers for every utility's TVM program can and will vary, a key strategy focus area for Duke Energy's TVM was to implement an end-to-end, data-driven solution, addressing threats over a multiyear period to drive reliability and program effectiveness. With this strategic focus as a driver, the utility was able to begin with the end in mind, limiting the time needed to consider the art of the possible.
- A deliberative approach to development and implementation is essential. This approach includes assessing options and desirability, determining viability, assessing feasibility and refining the solution. Following the assessment of options such as accuracy, data resolution or threat identification to meet work needs, a pilot or prescribed demo effort can be used to confirm viability and feasibility. Once viability and feasibility have been established, a pre-scale implementation provides an opportunity to refine the solution prior to full implementation, reducing the risks associated with user adoption.
- Flexibility and adaptability need to be primary considerations when technical options and feasibility are being discussed during the development phase. Because technology changes quickly and base-use case needs will evolve, building flexibility into the solution is vital. From an enterprise utility perspective, ensuring the adaptability of the data and technology solutions for other potential use cases, such as asset protection, transmission line engineering, distribution VM and corporate geographic information systems also is extremely important when practically supported within the business case. Because other potential use-case needs were considered during the development of the RSP and WorkPASS, the TVM data, applications and systems are leveraged by other organizations, such as the transmission line engineering and asset protection teams.

Successful implementation of Duke Energy's TVM's RSP and WorkPASS initiatives was made possible by addressing these three crucial elements and employing a robust change management effort within the organization as the technology-related initiatives were developed and implemented. Together, the RSP and WorkPASS applications provide Duke Energy TVM with the foundation necessary to meet the challenges associated with ever-increasing expectations. TDW

TIMOTHY J. "JACK" GARDNER (*Jack.Gardner3@duke-energy.com*) is Duke Energy's Manager for Transmission Vegetation Strategy and Support. His team is responsible for providing enterprise TVM strategy, business transformation, technology, and support. Gardner holds a BSCE degree from Virginia Tech and has been with Duke Energy for over 22 years, after 20 years at AEP. During his career, he has led and managed numerous Transmission Line, Vegetation and Remote Sensing initiatives, programs, and organizations. In addition to his current role, he led the WorkPASS development initiative as Product Owner, with several TVM Strategy personnel providing critical business process, technical, and change management direction during the development: Johnathan McQuaide, Bill Skrobutt, Alex Christie, Sherry Bumgardner, and Mark Ferrill.

BY **JOHN BONNIN**, SENIOR ENERGY CONSULTANT FOR AUTOGRID

Texas' DER Pilot Program will allow Texans with solar and battery solutions to contribute energy to the Texas grid during new bouts of extreme weather.
23713404 © Neutronman | Dreamstime.com

Virtual Power Plants Could Ease Grid Woes in Lone Star State

There's some hot news in Texas: Big innovations to maintain grid reliability are underway.

Texas is facing a reliability crisis for all seasons. During freezing temperatures in winter, Texans face severe power outages. In the summers spiking energy prices, power plant failures, and the threat of rolling blackouts plague the Texas power grid as well as other areas.. What's more, with the growing popularity of electric heating and cooling systems, as well as electric vehicles, Texans continue to add even more pressure to an already-strained grid.

But there's some hot news in Texas: Big innovations to maintain grid reliability are underway.

The Electric Reliability Council of Texas (ERCOT) and the Public Utility Commission of Texas (PUCT) have launched a pilot program to test how aggregated distributed energy resources (ADERs) can bridge the gap between residential rooftop solar + battery systems and the larger wholesale market.

Texas' DER Pilot Program is allowing Texans with solar and battery solutions to contribute energy to the Texas grid during new bouts of extreme weather.

Commissioner Will McAdams said that the development of these resources will "put consumers in control of their energy future" and marks the next step in a series of new market rules that will make Texas a leader in leveraging customer assets, such as electric vehicle chargers, heat pumps, and HVAC systems.

This pilot is particularly significant for Texas, as it is the only state to limit connections with wholesale markets in bordering states. This setup comes at a cost during extreme weather events, since power outages cannot be alleviated by energy contributions from nearby states. Additionally, Texas has not designed specific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policies to promote energy storage. For these reasons, as well as the state's reliance on a large fleet of peakers and its location in the epicenter of the country's oil and gas industry, Texas is an ideal candidate for a pilot that promises to build upon multiple areas of the state's recent energy challenges.

The ability to leverage customer assets to promote increased energy distribution is an essential piece in creating a more sustainable and reliable energy system. For Texas, a technology-agnostic approach is ideal, as it would create a blueprint to meet the needs of prosumers, the grid, the economy and the environment. DERs are diverse, so the software systems that manage and control them must be flexible enough to integrate with the products of any vendor. A sustainable VPP market in Texas, across the U.S., and worldwide requires technology-agnostic solutions that support customer choice and scale.

Not only is ERCOT embracing aggregated DERs, but it is also putting customer resources in the same arena as traditional utility grid-scale resources. DERs' market entrance fits into existing rules and operations with only minor adjustments. Compared to traditional power plants, megawatts from ADERs will have no preference or penalty. Many Texans argue that a benefit of an independent, isolated market like ERCOT, which operates solely under the authority of the Public Utility Commission of Texas, and not of the FERC, is this ability to move swiftly and accommodate technological changes that meet a market need.

In its initial testing phase, the ADER pilot aims to harness 80 megawatts (MW) of flexible resources on the ERCOT grid, which will pave the way for the rapid expansion of these types of energy sources in the coming years. Guidehouse Insights forecasts that more than 32 GW of DERs will come on-line in Texas during this decade alone. The entire Texas fleet of high-polluting peaker plants is approximately 30 gigawatts (GW). Based on Guidehouse's data, if these DERs are intelligently aggregated into VPPs, the state of Texas can conceivably eliminate reliance on peakers in less than 10 years.

The world is moving towards a level of system reliability and cost savings that can be achieved year-round with VPPs. Consider this: AutoGrid's AI-driven VPPs resulted in over 1,000 peak demand events, launched from 1 million devices. During two events in Hong Kong, 600,000 households were asked to cut back their power usage, and the resulting savings reached 300,000 kWh, equivalent to eliminating 110 tonnes of carbon emissions.

News of this launch isn't surprising, since many can vouch for the power of DERs in improving grid stability. It was only a matter of time until Texas began transforming its electrical grid into a distributed, decarbonized, and digitalized network of connected assets. TDW

JOHN BONNIN is a senior energy consultant for AutoGrid. He has over 30 years of industry experience, including 18 years at CPS Energy as vice president of Energy Supply and Market Operations. His focus was managing market risks to native load customers and optimal dispatch of CPS Energy's power generation fleet, which included over 1.5 GW renewable energy and 200 MW Demand Response capability. Bonnin has a M.S. in Management/Computer Resource Management from Webster University and a B.S. in Chemistry from LSU.

ELECTRIC UTILITY OPERATIONS

JULY 2023

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SMUD's ROW Stewardship

OUR JULY FEATURED LINEWORKER

Matt Richardson

Duke Energy Florida

- Born in Providence, Rhode Island.
- Married to his wife, April, for six years. They have a four-and-a-half year old son named Matt (MJ).
- Enjoys being on the boat with his family and friends to go fishing, lobstering, diving or going to an island to hang out for the day.
- Works out of the St. Petersburg Operations Center.
- Focusing on storm hardening projects and pole changeouts. With the way everything is being built up in downtown St. Petersburg, Florida, he says the lineworkers will be building new construction for a long time to come.

Early Years

Before I entered the utility industry, I climbed trees for a residential tree service. My wife brought up the opportunity, so I applied. I figured I already had the climbing part of it, so I gave it a shot. None of my relatives or friends were in the industry before I got into it, but it has inspired quite a few to look into it since then. My first job at Duke Energy was a groundman position. I went through the apprenticeship and passed all the tests to become a journeyman lineworker.

Day in the Life

My main responsibilities on a day-to-day basis are to run my truck and teach my apprentice. On a normal day I'll receive prints in the morning. My job is to get those jobs done correctly and safely. While completing the work, I'm teaching apprentices and making sure they get the opportunities they need so they can be journeymen lineworkers one day.

Challenges and Rewards

Some of challenges I face while working is the area I'm in. We are often called to respond to outages that can take us away from our day-to-day work. We work a lot of hours and get called in all through the night as well, but it is rewarding getting power back to customers who are out.

Memorable Storm

I have responded to storms in Florida and out of state from the Carolinas to Louisiana. My most recent storm was the most memorable. We responded to Hurricane Ian in October 2022. We traveled to Pine Island, which is very close to us in St. Petersburg, Florida. Upon entering the area, we saw poles on the ground as far as you could see. We rebuilt everything from the substation out. We had an opportunity to do some barge work and rebuilt a line on a beach in 2 ft to 4 ft of water. We took boats out there and waded through the water and set poles with a barge crane. We then climbed all the poles and put up the wire. We stayed in a camp and showered and slept in trailers. We were deployed for 12 days but due to the amount of work we did and sleeping conditions, it felt like a month. It was extremely hard work but very rewarding.

Matt Richardson (right) competes in Duke Energy Florida Lineman's Rodeo with teammate Chet Braden (left) in Winter Garden, Florida.

Safety Lesson

During my time here I have responded to a few emergency tickets with tree trimmers and electricians who got into our lines. When you show up and see these individuals being loaded up in ambulances or still in a bucket, it changes you. There have also been a couple accidents that involved my coworkers as well. When you see those types of events or even hear about them, they make you take a step back and realize how important safety really is.

Tools and Technology

The new compression tools and drills have changed the way we do work now. Battery-operated tools have helped us tremendously. There's no more leaning out and hand-pressing connections. Over a long period of time, this is going to save our shoulders. The new test equipment that we are getting now improves safety and productivity because we can identify underground cable with ease.

Future Plans

If I had to do it all over again, I would go into the power industry. This field of work is hard, it's demanding and it requires you to always be on your game. It's not easy, but it teaches you good qualities that can be used on and off the job. My plans for the future are to stay in the journeyman role, to continue learning and to teach everything I can to the next generation so they can become successful lineworkers. 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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Strive for Sustainability

SMUD achieves ROW Stewardship re-accreditation for its integrated vegetation management program.

By **ERIC BROWN**, Sacramento Municipal Utility District

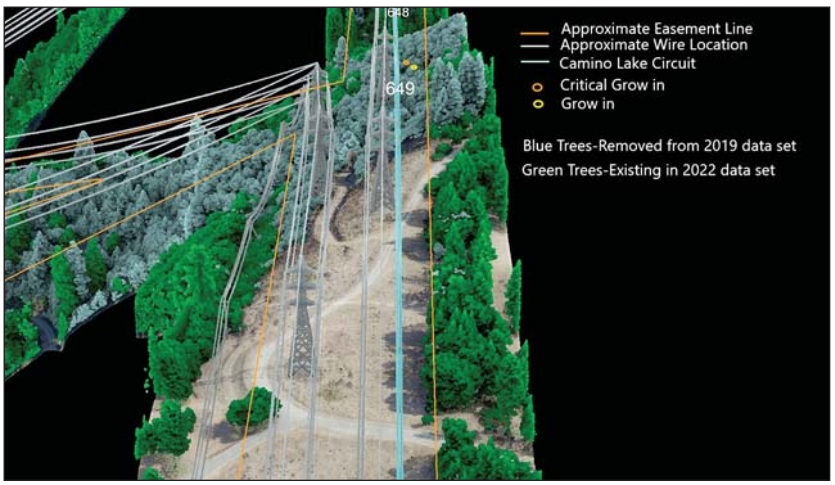
Sacramento Public Utility District (SMUD) manages 478 circuit miles of electric transmission lines traversing about 200 miles of right-of-way (ROW) in California. As the sixth largest publicly owned utility in the United States, SMUD is one of only seven North American utilities recognized as a ROW Steward for its sustainable integrated vegetation management (IVM) of electric transmission ROW systems.

The Right-of-Way Stewardship Council (ROWSC) recently recognized the utility with re-accreditation following a rigorous evaluation and audit process completed in December 2022. SMUD is only the third utility to achieve re-accreditation. Along with SMUD, the ROWSC currently recognizes the following other accredited utilities: AltaLink; Arizona Public Service (APS); Bonneville Power Administration (BPA); FirstEnergy; New York Power Authority (NYPA) and Vermont Electric Company (VELCO). One of the benefits to utilities participating in the program is to optimize implementation of IVM principles through feedback from industry experts/auditors during the accreditation assessment.

Becoming accredited by the ROWSC program required SMUD to demonstrate holistic forward-thinking and compre-

Lupine flowers bloom in a transmission ROW one year after shaded fuel break/forest health/integrated vegetation management (IVM) work on federal lands. Photo by SMUD, Eric Brown.

hensive problem-solving for its vegetation management program. The accreditation recognizes SMUD as an industry leader that can contribute to positive relationships with landowners, communities and land management and regulatory agencies. The ROWSC accreditation provides standards of excellence for environmental steward ship in IVM and presents the opportunity for utility companies to demonstrate commitment to such standards. While initially focused on the North American high-voltage transmission power grid, the program is adaptable to other ROW users like pipeline, roads and railways.



Remote sensing 3D Lidar Point Cloud, change detection Transmission showing risk reductions on private and utility owned lands (El Dorado County California) Photo by SMUD.

Investing in IVM

SMUD's vegetation management program primarily covers two areas: Eldorado County, where SMUD operates its Upper American River Hydroelectric Project, and Sacramento County. The vegetation management program recently established a collaboration with the USDA Forest Service, which supports both risk reduction and forest health at a landscape-level execution.

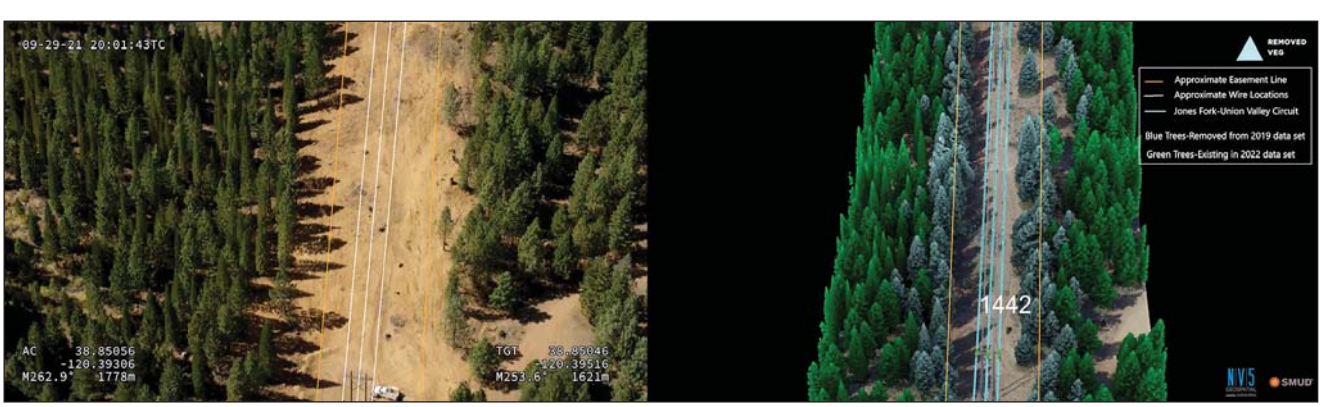
Back in 2015, the ROWSC first recognized SMUD for its IVM program. Based on regular annual desk reviews and a mid-cycle field review, the council has continued the gold standard recognition. The ROWSC, formed in 2013, established rigorous management gold standards or best management practices (BMP) based on a set of predetermined principles. It requires a formal application process and enlists third-party auditors to ensure demonstrated compliance with the standards.

The ROWSC Accreditation Standards for Assessing Integrated Vegetation Management (IVM) Excellence establish the technical requirements for applicants seeking ROWSC accreditation. The standards are applied in an independent audit of an applicant's IVM program to aid in identifying excellence. Third-party recognition from industry subject matter experts ensures an independent, proven process to convey credibility and bring recognition to IVM programs.

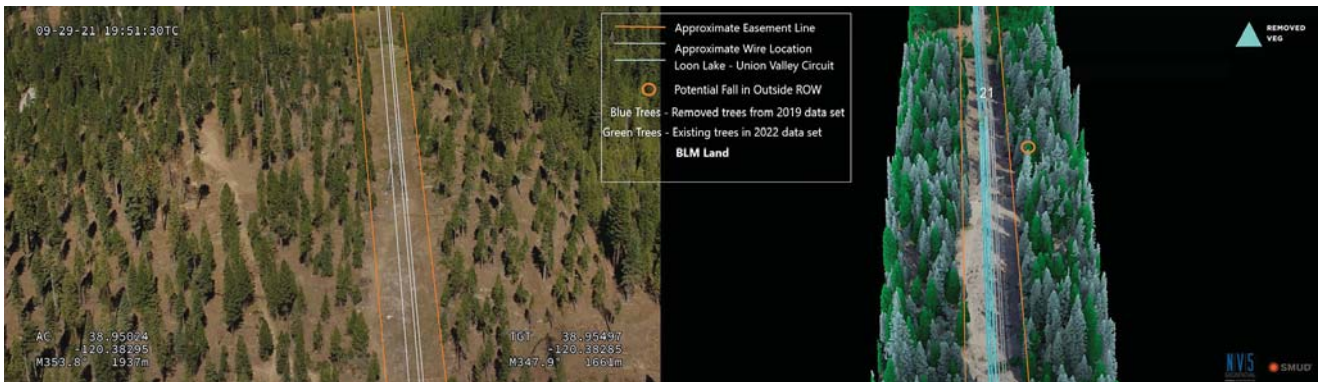
ROWSC has established top-tier management standards based on 10 principles and 35 criteria points that codify IVM, emphasizing Environmental Social & Governance performance. These principles address compliance with laws, standards, superior practices and BMPs; tenure and use rights and responsibilities; community relations; management planning; understanding pest and ecosystem dynamics; establishing tolerance levels; compilation of an array of vegetation maintenance techniques; accounting for economic and ecological effects of treatments; site-specific implementation of treatments; and monitoring and adaptive management.

Specific highlights from SMUD's ROWSC re-accreditation audit included SMUD's support of high-profile local civic activities, including the Community Shade Program and partnership with The Sacramento Tree Foundation. Through this program, the utility has partnered to plant more than 600,000 trees and expanded its offerings to maximize carbon sequestration. The utility also has an active partnership with Sacramento County Parks & American River Parkway Foundation to improve wildlife, reduce noxious weeds and develop pollinator habitat.

SMUD's approaches to adjust vegetation management practices on private and agency lands helps to ensure collaborative outcomes where appropriate. SMUD personnel have been strong leaders in the industry, and SMUD is providing leadership in fuel reduction/forest health demonstration projects for other utilities in fire-prone regions.



Transmission showing risk reductions/forest health work both inside and outside easement on federal lands (El Dorado County California). Photo by SMUD.



Transmission showing risk reductions and extensive "shaded fuel break/forest health) both inside and outside easement on industrial timberlands lands, (El Dorado County California) Photo by SMUD.

Leveraging Technology

SMUD has been leading collaborative problem solving for vegetation management with innovative technology. By effectively using remote sensing technology like LiDAR, imagery and analytics, SMUD can provide laser-focused outcomes for the purpose of risk reduction.

The advanced unique use of technology has allowed SMUD to establish baseline conditions along ROW and geospatially quantify all risks across the system. This has provided comprehensive and effective risk reduction strategies. SMUD's holistic and targeted IVM approach contributes to improved wildlife and habitat results, and overall environmental stewardship benefits because treatments are more consistent and better informed by baseline data.

While the use of remote sensing technology may no longer be considered cutting-edge, SMUD's application, analytics and unique application/approach has included applying the technology outside the ROW to expand easement risk reduction and forest health work on private, federal and private industrial timberlands. This extension of the technology is unique among utilities and an innovative part of SMUD's IVM leadership contributing to their ROWSC accreditation. The use of technology in this way has strengthened SMUD partnerships with private, industrial timberland owners and federal landowners.

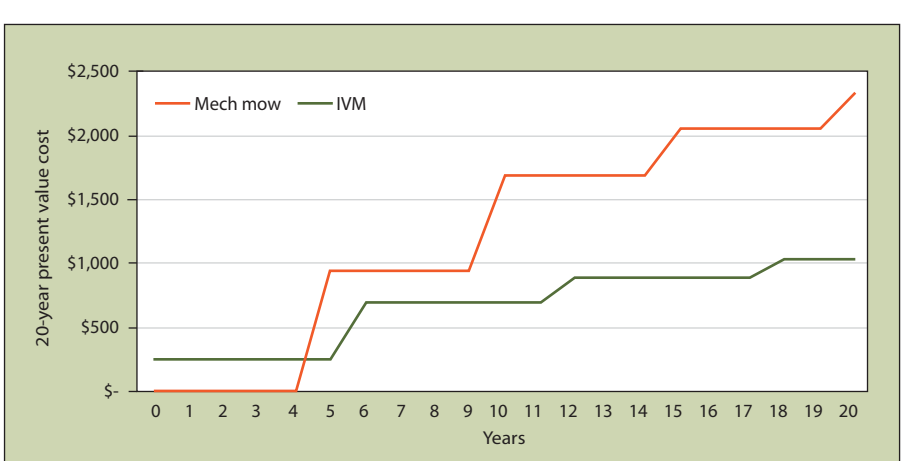
Through these partnerships, diverse landowners and managers are working collaboratively at the landscape and watershed levels on forest health projects. These efforts provide multiple environmental and social benefits with improved forest conditions, less community disruption and improved safety conditions. The innovative and collaborative partnerships that SMUD has developed through the shared use of advanced technology also leverages labor and programmatic costs.

ROW Research

The advantages of IVM have been demonstrated across many uses, including public safety, operational risks, recreational use, public nuisance, site disturbance, water quality, compatible and incompatible vegetation and a range of wildlife species, according to The Cost Efficiency of IVM by John Goodfellow of BioCompliance Consulting. Research has established a preliminary business case for IVM on electric transmission ROW by applying least-cost economic analysis methods focusing exclusively on the direct cost to the utility for vegetation maintenance work practices. That approach limited consideration of the benefits of IVM compared to simply avoided cost. However, indirect costs and benefits of IVM are important considerations.

About 450,000 miles of electric transmission lines operate at 35 kV to 765 kV across North America, with a total land area managed as electric transmission ROW estimated between 9 million to 11 million acres. An additional 306,000 miles of natural gas and liquid petroleum pipeline represents an estimated 2 million acres of land in North America. Reluctance by some vegetation managers to adopt IVM is often based on the perception that it is more expensive when compared to controlling brush by repeated mowing or just applying traditional methods in a linear fashion.

IVM-based ROW maintenance programs are intended to create, promote and conserve stable native diverse plant communities. A variety of vegetation maintenance methods and combinations of techniques are used to promote sustainable plant communities compatible with the



Cost comparison of vegetation management strategies. Photo by SMUD.

intended use of the site, and to control, discourage or prevent the establishment of incompatible plants that may create a variety of risks. Industry standard ANSI A300 Part 7 (2019) and ISA BMP, Integrated Vegetation Management 3rd Edition (2019), define IVM on utility ROW. The ROW Stewardship Council's IVM 2016 Accreditation Requirements define IVM principles and practices for ROW in detail.

A research effort completed in 2019 expanded the evaluation of IVM outcomes to include the development of an enhanced least-cost analysis model and consideration of the many benefits of IVM on electric and gas utility ROW. The figure below (Susie, include the chart from Goodfellow) shows a 20-year cost comparison of mechanical mowing-only treatments v. IVM treatments. The figure shows that, because of the added cost of herbicide treatment during initial clearing, the IVM strategy is initially the higher. At the time of the first maintenance event (four years), the cost of mechanical maintenance overtakes that of the IVM and is double the IVM cost after 20 years. The findings of the research presented a holistic assessment that includes economic considerations, societal implications and environmental externalities associated with IVM. In doing so, it established IVM as the least-costly and most beneficial ROW vegetation management strategy.

ROWSC accreditation provides IVM practitioners in the utility sector with direct and indirect benefits associated with the adoption of an IVM-based strategy. Through this approach, utility companies demonstrate their commitment to environmental stewardship, environmental, social and governance (ESG) principles and the communities they serve. Accredited utilities maintain and sustain power system reliability while enhancing environmental stewardship. ROWSC principles guide member utilities in implementing and continually improving their vegetation management practices.

ROWSC accreditation holds value to the public. ROWSC standards help to foster more comprehensive strategic communication, education and engagement with the public and internal and external stakeholders. ROWSC accreditation provides assurance to regulatory agencies that IVM practitioners meet the program's rigorous principles while potentially reducing the need for new regulation. This has the potential to improve relations with state and federal agencies. ROWSC principles emphasize methods that reduce incompatible vegetation and establish a sustainable plant community, which can reduce costs of treatment efforts for utilities.

Editor' s Note: SMUD will be hosting the 2023 T&D World Live Conference and Exhibition in September. See *https://events.tdworld.com/2023* to register. TDW

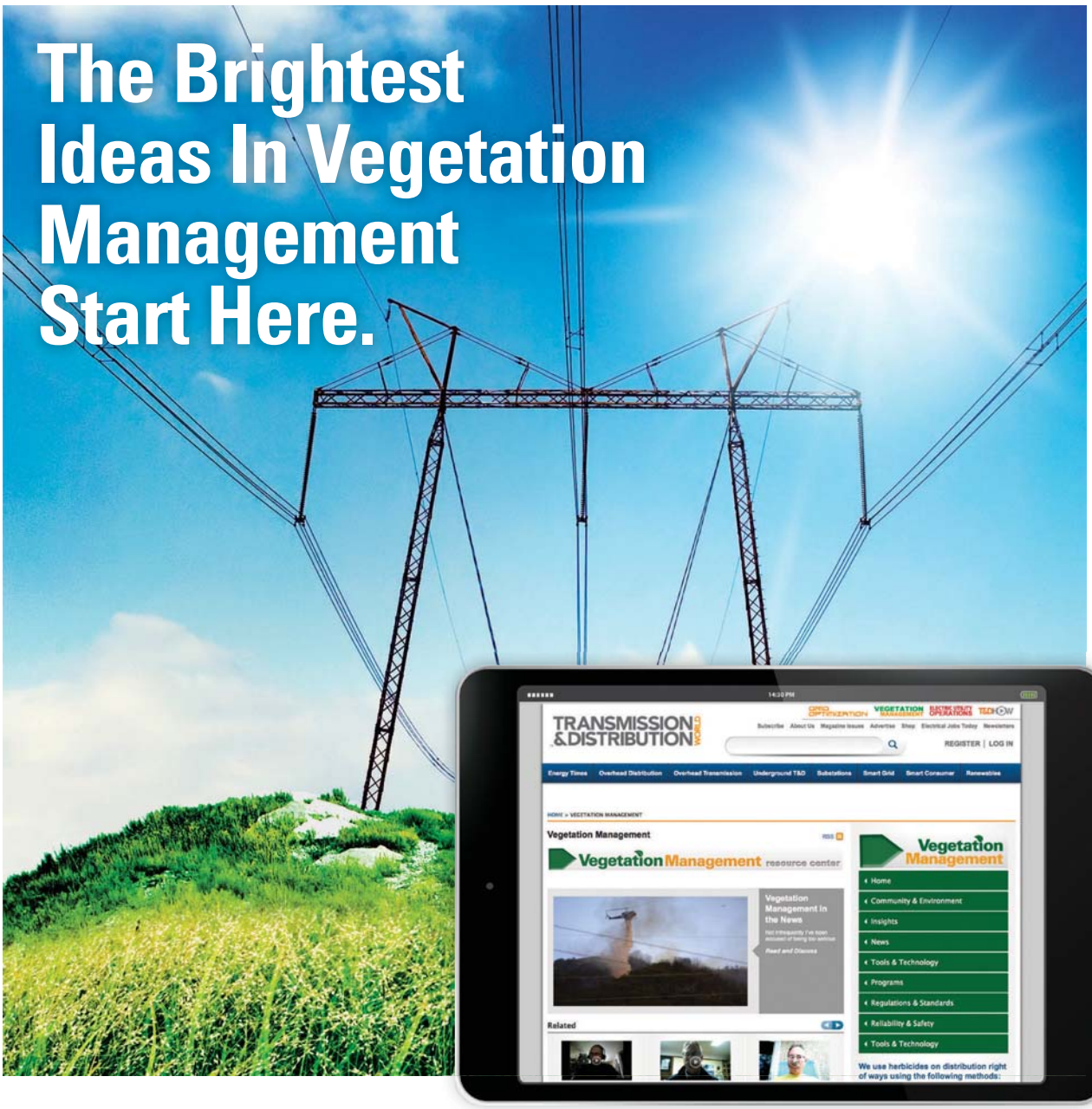
ERIC BROWN (*Eric.Brown@smud.org*) is T&D manager grid assets – vegetation management for Sacramento Municipal Utility District.

Parting Shot

Photo courtesy of **FirstEnergy**

Over the past three years, FirstEnergy's Ohio electric companies collectively invested more than $500 million to enhance their electric grid. They installed hundreds of automated reclosing devices, as pictured here, in substations and along the power lines that will help limit the frequency, duration and scope of service interruptions, especially during severe weather.

The Brightest Ideas In Vegetation Management Start Here.



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SRP's Bolster substation battery system uses a series of batteries connected directly to the energy grid. The batteries can be recharged overnight then discharged during peak energy usage periods. Photo by Salt River Project.

SRP Learns From the Past

Salt River Project makes new battery investments based on prior experience and hones its operational approach amid Arizona's growing energy demand.

By **CHRIS JANICK**, Salt River Project

In the rapidly growing Phoenix, Arizona, U.S., metropolitan area where hot summer temperatures, intense monsoon storms, population growth and regional resource adequacy challenges continue to stress the energy grid, Salt River Project remains committed to providing reliable power to around 1.1 million customers. Peak electricity demand in the SRP's service territory is forecasted to grow by approximately 900 MW by 2025, which represents a 12% increase from today. This amount of power equates to serving about 200,000 average size homes.

This generation capacity does not currently exist in the market, meaning SRP needs to acquire or build new power generation resources as well as storage resources to serve this rapidly increasing demand. Battery storage systems represent a promising technology to help serve the demand. For this reason, SRP is an early adopter and one of the Western region's largest investors in this evolving technology. However, SRP also recognizes the electric utility industry still needs more operating experience with this technology before it can rely on batteries to support transition to zero-carbon generation resources.

Power Resource Portfolio

SRP continues to strengthen its resource planning strategy by developing a diverse and reliable power resource mix. It has chosen an "and" strategy to meet its customers' needs, which means it is investing in a wide variety of resources, including utility-scale solar, flexible natural gas, wind, biomass, pumped hydro storage and others. As a not-for-profit, public power utility, SRP typically has sought many of its renewable generation and storage projects through power purchase agreements with developers.

Battery systems have become one of the only relatively quick-to-deploy options for adding more renewable resources with energy output and storage capabilities when needed on the power grid. The ability to implement them in a timely manner is largely driven by their regulatory and siting processes, which do not require considerations for fuel or water availability.

Batteries also present unique, multifaceted value. One key asset is their ability to store energy at a lower cost and deploy it when demand is highest and energy generation most expensive — such as during peak demand periods that occur in the early

SRP announced an additional 100 MW, 400 MWh of battery storage to be added to the existing Saint Solar facility in Coolidge, AZ. Photo by Salt River Project.

evening hours of summer. This benefit is extremely valuable in the Phoenix market, where summer temperatures often exceed 110°F (43°C). Batteries also have fast-ramping capacity and peaking capacity, meaning once charged, they can be available on the grid very quickly.

In addition, they provide ancillary services such as regulation, contingency reserves and frequency response, which can help to smooth out fluctuations in power grid operations. However, with these ancillary services also comes a draining of the batteries' capacity, at times reducing the ability to discharge during peak demand periods.

SRP has been an early adopter and investor of storage technology and resources while also transforming its system to be more sustainable. Its battery storage capacity is expected to total 1100

Plus Power rendering of the Sierra Estrella battery storage system to be located in Avondale, AZ. Photo by Plus Power.

MW by the summer of 2024, which is significant compared to a total of only 8000 MW in the entire U.S. as of late 2022.

Looking Back To Move Forward

With the battery storage projects SRP will have on-line in just a couple of years, its storage capacity will be capable of providing more than 10% of the expected peak-hour electricity demand. As a result, SRP will rely more greatly on this technology and need additional operational knowledge. With each new storage project underway, SRP and other electric utilities need to use data and information gained from what did and did not work with previous battery projects to inform future decisions.

One of SRP's first battery pilot projects was Pinal Central Solar Energy Center located in Casa Grande, Arizona, which became operational in April 2018. The 10-MW battery system, powered by 20 MW of solar generation, continues to deliver power to SRP's energy grid while also providing data and experience that has proven useful in designing future developments. SRP's other battery pilot project was the Dorman battery, located in Chandler, Arizona, which went on-line in January 2019. The 10-MW, four-hour system is no longer in operation because of a thermal runaway event that occurred in April 2022. The developer of the Dorman storage system continues to investigate the cause of this event and how to improve the safety of these systems to prevent a similar event from happening.

Based on growing industry understanding of the Dorman event and similar failures, technology and designs of battery storage have improved dramatically. Battery energy storage systems (BESS) are now often designed in external cabinets, so if a battery fire were to occur, it would be extremely isolated and only impact cells inside the individual storage cabinet, as

The Pinal Central Solar Energy Center became operational in 2018 and consists of a 10-MW battery system powered by 20 MW of solar generation. Photo by Salt River Project.

opposed to the possibility of impacting other units in the same storage facility or building.

Both of SRP's pilot battery projects, though smaller in scale compared to new systems it is bringing on-line, have provided insight and important operational data to SRP, which the utility industry can build on. As these pilots are developer owned and operated, SRP previously needed to submit dispatch schedules to developers 24 hours in advance of the batteries' deployment on the grid. This limits the operational value to SRP because much can change within a 24-hour window, including the optimal time for the storage to be deployed. SRP learned the value of having direct oversight of these systems' charging and dispatching. Having this control and insight is now a necessary facet SRP includes in all storage resource contracts.

Projects In The Works

SRP's Bolster substation battery, the largest currently on its system, came on-line in September 2021. The 25-MW, 100-MWh grid-charged battery uses Tesla Megapacks and can be recharged overnight, then used during times of peak energy usage to help counter rising demand. SRP has direct dispatchability of this system and gathers data on the system's operations throughout the year, including the best times to deploy its storage as peak demand periods change from season to season.

SRP likely will use battery storage for some of its flexibility-related operations, too, which could mean managing overgeneration of power during the spring or ramping up to quickly meet peak demand periods in the fall. In addition, SRP recently began testing market utilization of this battery as a participating resource in the Western Energy Imbalance Market.

SRP also announced several upcoming grid- and solar-charged battery storage projects, including Sonoran Energy Center. Announced in 2019, the 1040-MWh BESS will be the largest solar-charged battery system in Arizona when it comes on-line in 2023. Also planned to come on-line in 2023, the Storey Energy Center in Coolidge, Arizona, will be an 88-MW, 264-MWh BESS charged by utility-scale solar. In January 2022, SRP announced an additional 100 MW and 400 MWh of battery storage to be added to its existing Saint Solar facility in 2023. SRP further increased its commitment to batteries in October 2022 with the announcement of two new projects that will add a combined 340 MW of energy storage using Tesla Lithium-ion technology.

SRP also will seek approval from its board of directors soon on a long-duration storage project at its Copper Crossing Energy and Research Center in Florence, Arizona, to add up to three storage pilot projects using emerging non-Lithium-ion technologies.

Opportunities And Challenges

Storage projects have become an integral part of most utilities' resource planning processes, especially as utilities across the Western U.S. region, including SRP, retire their fossil-burning resources. Utilities have a greater reliance on batteries for activities like smoothing out variability from renewables and providing support during other fluctuations and system events.

However, ongoing supply chain issues have added strain on the transition to renewable resources, with raw materials for BESSs becoming increasingly difficult and expensive to acquire. In addition, most sizable battery projects on the U.S. grid are less than a decade old. Developers and utilities are still learning how these systems fit into the larger operational picture with similar levels of reliability as other more traditional resources.

Managing the battery discharge and charge cycles to serve customers reliably and cost effectively is a top priority, but this can be complicated by restrictions and requirements from developers. The industry also does not know how long new battery technologies will last in a desert environment. The batteries SRP is currently deploying only have capacity for up to four hours of storage and, like any resource, they cannot provide all their reliability functions at the same time. This means operational decisions, such as when and how to use batteries, will need to be made on an ongoing basis, which will affect their ability to support increasing demand.

The utility industry is still grappling with how batteries will provide enough capacity and flexibility to reliably transition to zero-carbon resource portfolios. Until utilities have a better grasp on how batteries will be a trusted solution to adding more renewables, traditional thermal generation must still play a role in continuing to achieve low-cost, reliable power for customers. As SRP continues to add more renewable resources, it also will need to add flexible resources, such as quick-ramping natural gas, to its portfolio to ensure a reliable power supply.

Innovating And Adapting

The need to shift to more sustainable technologies is urgent, but it is just as critical to ensure the transformation happens reliably and successfully. Failing to plan and prepare for long-term growth and increasing electricity demand is a surefire way to increase the risk of regional power shortages.

With the changing dynamic and increased pressure on the electric sector to achieve broad environmental and societal goals, traditional resource planning methods are becoming insufficient. Electric utilities also must partner with stakeholders across industries to optimally develop a safe, reliable, affordable and environmentally responsible power system. SRP is currently doing this through its integrated system plan.

Batteries will help SRP to meet rising energy demand in the near term and also act as the foray into incorporating a more diverse storage resource future. SRP will continue to evaluate its storage portfolio while investigating long-term options that will ensure a sustainable, reliable and affordable energy supply. These include additional pumped hydro and small modular nuclear technology. There is still much more for SRP and other utilities to learn, and many in the industry plan to use these next several years learning as much as possible from the storage technologies currently being developed and deployed. TDW

CHRIS JANICK (*chris.janick@srpnet.com*) is senior director of power delivery at Salt River Project (SRP), where he has worked since 2000. Prior to serving in his current role, he oversaw several other departments at SRP, including as director of protection, automation and control; director of electric reliability compliance; and plant manager of SRP's Agua Fria generating station in Glendale, Arizona. He holds a bachelor's degree in chemical engineering from Arizona State University.

Electric vehicle charging station near an Alaska highway.
100079487 © Bounder32h | Dreamstime.com

EV Battery Strategies for Sub-Freezing Weather

With electric vehicles on the rise in Alaska, the University of Alaska Fairbanks investigates research questions on EVs in extreme cold temperatures.

By **MICHELLE WILBER**, University of Alaska

Climate change typically means warmer weather, but grid operators also are experiencing more extreme cold spells. These colder temperatures are a common hesitancy for wider adoption of electrification — whether that be electric vehicles (EVs), drones or other field operations equipment.

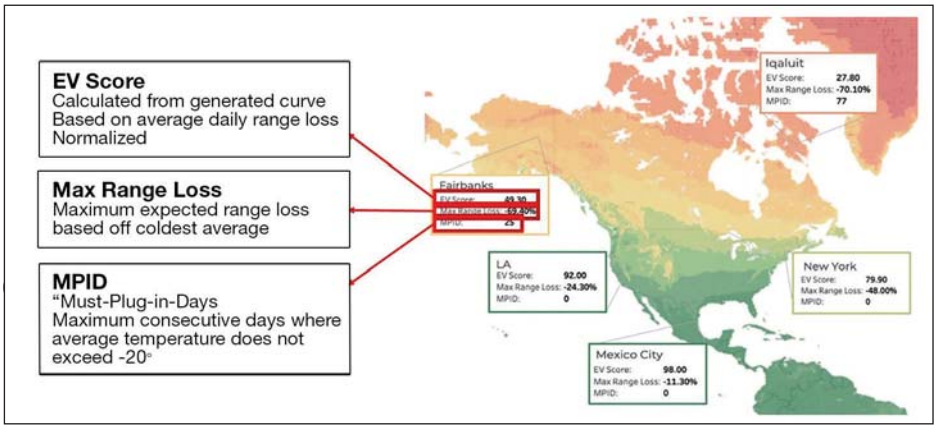
Despite the colder temperatures, interest in EVs is increasing rapidly in Alaska. Because EVs interact directly with electrical generation systems — distributed and community — and have the potential to act as dispatchable loads or storage to support electric grid stability, the Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks (UAF) is investigating research questions pertinent to EVs in Alaska.

Cold Region Research

As early as 2009, a research team at the UAF Transportation Center began studying EVs in Alaska. Although the technology was in a very different state at that time (vehicles were either self-built or conversions), the research team's *Feasibility Study of Electric Cars in Cold Regions* report noted: "Electric vehicles can be a viable option for certain users in the subarctic and arctic communities."

Since then, the state has had a large uptake of plug-in EVs in Southeast Alaska, where hydroelectric power enables low costs, the limited size of road systems largely negates driving range anxiety, the climate is relatively temperate and consumers can directly access used EVs from the Lower 48 by ferry.

Every six months, the member-owned Chugach Electric Association (CEA) conducts a count of EVs registered in Alaska. The number of registered EVs in Alaska, and the municipality of Anchorage in particular, has risen steadily in recent years. CEA's report tallies two types of EVs that charge from the electric grid: battery electric vehicles (BEVs) that run solely on electricity stored in batteries, commonly with a range of 200 miles to 300 miles or more (322 km to 483 km), and plug-in hybrid electric vehicles (PHEVs) that typically have a more limited all-electric range, often 25 miles to 40 miles (40 km to 64 km), before switching over to an internal combustion drivetrain.



ACEP EV map.

However, cold-weather concerns are not limited to Alaska. As a region with a high uptake of EVs and ambitious goals for transitioning to EVs, Norway is a leader in operating EVs in cold climates. Despite overall progress in Norway, driving-range anxiety in cold temperatures remains a challenge to widespread EV adoption. A report on electromobility in Norway, published in the August 2015 issue of Research in Transportation Economics, addresses concerns related to driving anxiety in cold environments, such as operational performance and battery degradation.

Interactive EV Temperature Map

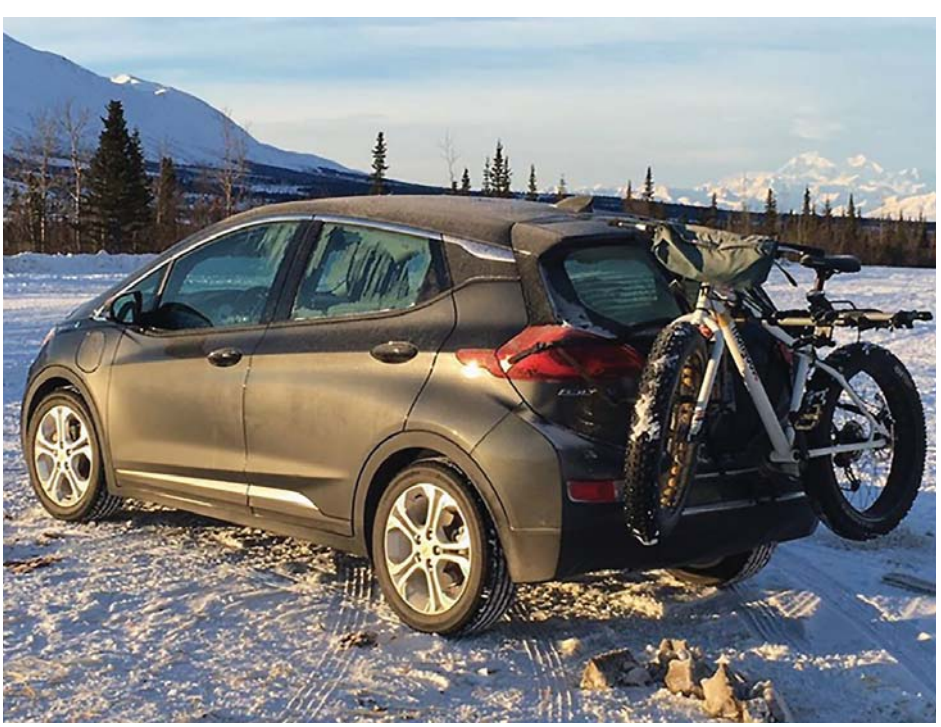
In 2020, ACEP worked with the University of Washington's Data Intensive Research Enabling Clean Technologies (DIRECT) program to gather EV and temperature data into a set of metrics. This work led to the publication of an online EV temperature map that shows three metrics related to temperature effects on performance. Users of the interactive global map can see how EVs may perform in their locale, which helps to address temperature uncertainties.

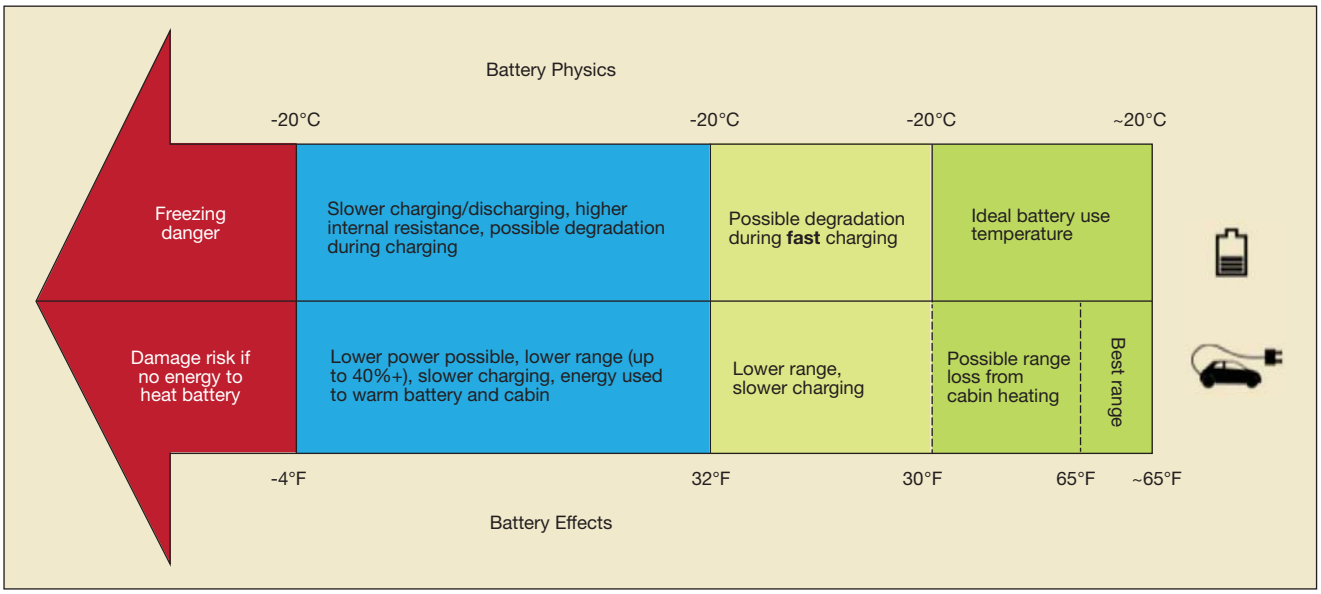
One metric is a normalized EV score based on the average daily range loss for any location on land, calculated from a fit of driving range loss vs. temperature, using 10 years of NASA temperature data. The second metric is the maximum expected range loss, based on the coldest temperature reached in the last 10 years. The third metric is must plug-in days (MPID), which is the maximum number of consecutive days in the 10-year temperature record that the average temperature did not exceed –20°C (–4°F) — the approximate temperature at which an unplugged EV may be permanently damaged.

These metrics can be used to help predict performance and efficiency or inform EV strategies in different regions of the world. Looking at the EV scores, much of China, Russia, Europe, Iceland, Greenland, Canada, the northern U.S. and mountainous regions of the world have scores overlapping with those of Alaska.

Cold-Weather Effects

Broadly speaking, cold temperatures can have two negative consequences on EVs: reductions in operational performance and battery degradation. Operational performance issues include a diminished driving range caused by the battery, cabin and other heating loads as well as lower energy and power available from cold batteries. In addition to cold-weather issues that are unique to EVs, reductions in operational performance can be caused by traction and other environmental conditions that affect all


Alaska has had a large uptake of plug-in EVs in the Southeast. Credit: Kirk Martakis.



Low temperature regimes for EVs: The top half shows effects of cold temperatures on batteries due totheir physics. Most of these effects are prevented through battery management and thermal management systems (e.g., heating the battery or charging it more slowly). The bottom half shows common operational effects, up to the possibility of battery damage if stored for extended perios at temperatures below -20C° (-4°F) without access to adequate power to run the battery heater.
Source: Compiled by Michelle Wilber.

vehicles. On the other hand, battery degradation occurs when cold temperatures damage an EV battery, which can shorten a vehicle's life span.

The cold-weather performance of different EV models may vary because battery technologies, battery heating and management systems, and cabin heating technologies sometimes differ. However, many of the proprietary details for commercially available models are not public knowledge.

Of the publicly available knowledge, operational performance information is generally documented in the form of driving range and data reports from brief driving tests on a limited number of EVs by researchers and others as well as anecdotal information shared by owners. Meanwhile, battery degradation has been investigated by researchers using battery models, theory and lab testing.

Managing The Effects

To manage cold-weather effects on batteries, an operational strategy such as a battery thermal management system (BTMS) is used that allows battery heating to maintain an optimal temperature range. When EVs are not plugged in to an external power source, they must power the BTMS from the battery itself, although some vehicles do not power the BTMS unless it is plugged in.

Any solution must balance the cost and other trade-offs between reduced battery health (and thus life) and the cost of the system to heat the battery. BTMS costs accrue from the complexity and extra weight of components, the cost of electricity and reduced battery cycle life. One study, Thermal Management of a Hybrid Electric Vehicle in Cold Weather, concluded parking outside at work or overnight without plugging in are issues with the actual BTMS strategies of common EVs and hybrid EVs — mainly because aging (incremental degradation of the energy capacity of the battery) as a result of cold temperatures is not considered in the development of the BTMS.

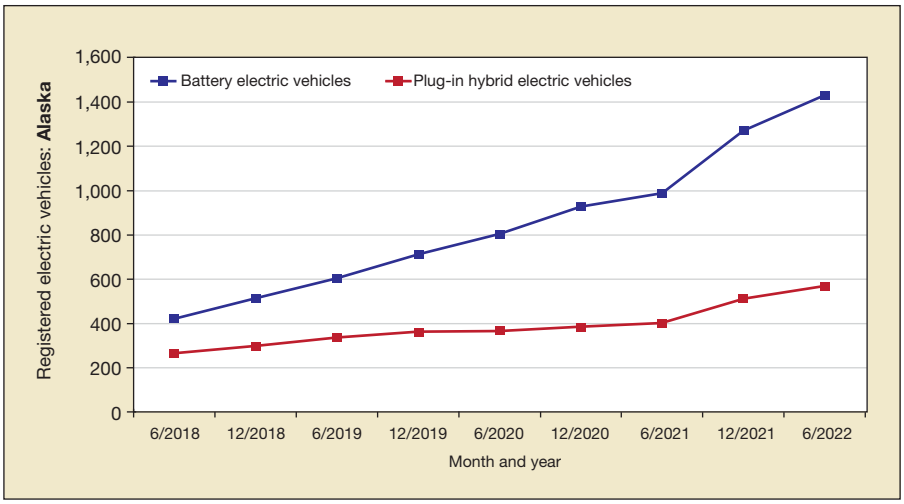
A study on "Battery Warm-Up Methodologies at Subzero Temperatures for Automotive Applications," published in the March 2020 issue of *Progress in Energy and Combustion Science*, provided a review of literature published about battery heating research, finding there are two primary battery heating strategies:

- In the first strategy, an external source transfers heat to the battery convectively or conductively. Convective options include air, liquid and heat-pump heating, whereas conductive options include resistance, Peltier-effect, heat pipe, phase change materials and burner heating.
- In the second strategy, internal resistance is generated from a current applied to the battery itself, thereby heating the battery from the inside. The self-heating

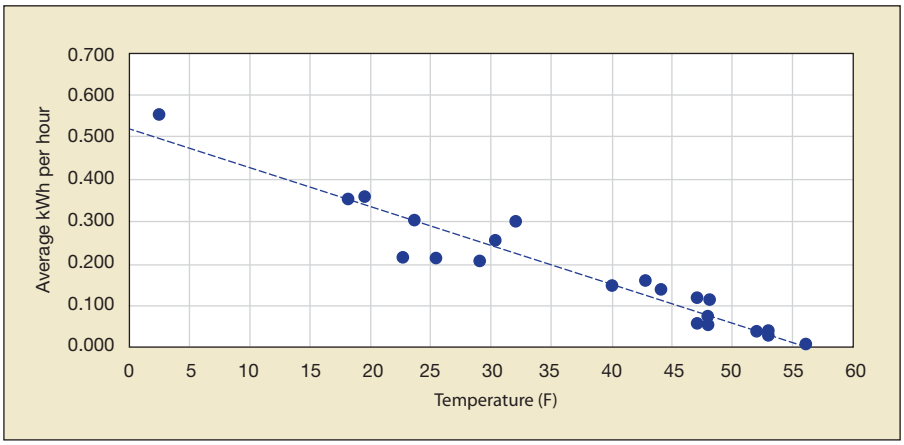
Lithium-ion battery (SHLB) is one recent example of this technology.

Both strategies have their weaknesses. On the one hand, external heat sources result in longer warm-up times, less temperature uniformity (which affects battery performance and health) and more energy consumption. On the other hand, internal heating must be designed carefully to use current levels and durations that do not cause excessive damage and, therefore, are harder to implement.

The SHLB attempts to minimize the trade-offs between pre-heating performance, energy consumption and degradation. This battery was developed to self-heat to avoid power drain at temperatures below 0°C (32°F) and has been upgraded to allow fast charging down to at least –43°C (–45°F). Two aspects of the SHLB — nickel foil inside the battery cell (attached to the negative terminal on one end and forming a third external terminal on the other end) and a temperature sensor attached to a switch — allow current to flow through and heat the foil. Once the battery is internally heated above room temperature, the switch automatically opens to allow charging. Research indicates the SHLB can perform 4500 cycles of fast charging at 0°C (32°F) before it reaches 20% capacity loss, where a standard Li-ion battery would only perform 50 cycles to the same capacity loss. This gives EVs with SHLBs approximately 280,000 miles (450,616 km) of driving with a lifetime of 12.5 years, which is longer than most automotive warranties.



Registered electric vehicles in Alaska. Credit: Chugach Electric Association.



Energy used while parked vs. average temperature (average kWh per hour of charge). Data for Chugach Electric Association's 2018 Chevrolet Bolt parked outside in Anchorage, showing average usage overnight while plugged in and already fully charged. Data courtesy of Sean Skaling.

Battery Heating Energy Costs

According to lab testing, an external heating source for an EV BTMS generally requires less energy than an engine block heater for an internal combustion engine (ICE).

Of the lab-tested external heating options reviewed in the Battery Warm-Up Methodologies at Subzero Temperatures for Automotive Applications study, most options required no more than 40 W in 35 minutes to heat the batteries by 20°C to 40°C (68°F to 104°F) in temperatures as low as –25°C (–13°F). EV batteries must be maintained above –20°C (–4°F) to prevent permanent degradation, and consumer acceptance may be greater for a vehicle that is always ready to drive without having to wait to warm the battery. This expectation may necessitate continual heating throughout the day, instead of a single heating event before driving.

In a real-world setting, energy use data logged by CEA for its Chevrolet Bolt while plugged in outdoors overnight in Anchorage, Alaska, indicated the car drew an average of about 500 W at

–18°C (0°F). The energy consumption of a BTMS is expected to be even greater in colder temperatures.

By comparison, most ICE block heaters require 400 W to 750 W and are recommended to be plugged in for 2 hours at –7°C (20°F) and 4 hours when temperatures are below –20°C (–4°F), as summarized by Manitoba Hydro in an overview on its Power Smart residential program. Despite these recommendations, many people plug in car block heaters (often in conjunction with battery blankets and oil pan heaters) at home and at work continuously during extremely low temperatures. ICEs generally do not suffer permanent damage if stored unheated in extreme cold, except perhaps to the starter battery, which can be brought indoors.

Energy costs for battery heating strategies can be extrapolated from real-world data. In Anchorage, Alaska, energy use for CEA's Chevrolet Bolt was logged when fully charged and plugged in outdoors overnight. In looking at the data, heating energy use is approximately linear with temperature, at least between about –18°C (0°F) and 13°C (55°F). Parking this EV outdoors in Anchorage for 11 hours at about –7°C (20°F) costs roughly $0.75, with electricity priced at $0.20/kWh. For comparison, it is estimated the cost of cold-starting a gas engine is $0.30/day. A 400-W engine block heater plugged in at –7°C (20°F) for 2 hours would cost $0.16. This is about an extra $0.60 for the EV overnight.

If the trend stays linear, this means about $0.87 to $1.01 kWh/hr average use while parked fully charged at –40°C (–40°F). For a full 24 hours, this is about 24 kWh, or $4.80 total to keep warm. A block heater plugged in for 24 hours would have to draw more than 1000 W of power to be more expensive. This impacts the economics of fueling an EV in extremely cold climates. The data currently available for energy used while parked and driving are incorporated into an online calculator for Alaskans to investigate the cost and emissions of an EV vs. an ICE.

Future Research

Given the performance of today's commercially available EVs in extreme cold temperatures, there is a need for better battery thermal management or cabin heating strategies for cold regions.

Opportunities for further research include the following:

- Test self-heating batteries.
- Collect and analyze data on power draw vs. temperature for different EV models while charging and while fully charged.
- Test levels one, two and three nominal charging speeds vs. temperature.
- Collect and analyze data on maximum range and energy use per mile vs. temperature for different EV models.
- Evaluate the change in maximum range over time (years) for several EV models parked outside in ambient air temperatures.
- Investigate the effects of extreme cold on EVs parked in ambient air temperatures but not plugged in (for example, minimum starting temperature, loss in battery state of charge with time and battery recovery when brought back into a warm environment). Testing to the point of significant damage or failure (that is, partial or total loss of battery capacity) would provide useful information yet would also incur substantial expenses.
- Develop a workable electric all-terrain vehicle and snow machine for rural Alaska using Lithium-titanate batteries for their cold performance.
- Investigate secondary, external and portable cabin heat sources that could alleviate the draw on the main battery for heating (for example, heat packs). TDW

MICHELLE WILBER is a research engineer at Alaska Center for Energy and Power (ACEP), University of Alaska Fairbanks, where she works on projects ranging from investigating solar energy potential in Alaska to analyzing electric vehicle energy use in the state.Wilber has a bachelor's degree in astronomy from the California Institute of Technology and a MSME degree from the University of Alaska Anchorage. She has worked as an engineering geologist, as an organic gardening coordinator, in energy-efficiency outreach, and as a park ranger in Katmai National Park and Preserve.

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Drone Service Provider Management

Sharper Shape is launching drone service providers (DSP) management. The company recently announced a contract with the Volatus Aerospace group of companies. DSP Management provides a digital platform (CORE) for drone service providers to coordinate, manage and deliver data collection projects in one place. The service is not limited to DSPs but also arborists and inspection companies that use unmanned aerial vehicles (UAVs) to inspect or work on utility transmission and distribution systems, such as power lines. CORE is available through a web browser or as an app, allowing it to be used remotely and in real-time in the field.

CORE allows drone operators the capability to transform how it collects, displays and shares data with its customers. Typical pain points tend to include the planning and administrative processes associated with inspections, and the inconsistency of systems and software from spreadsheets to visualization tools. DSP CORE eliminates these issues while offering a user interface that translates data, giving utilities a clearer, real-time view of their asset.

Sharper Shape | *https://sharpershape.com*

Deep Drilling Tool

GA Drilling has conducted the first public demonstration of its new deep drilling tool, ANCHORBIT. GA Drilling developed the tool to materially cut the cost of deep geothermal drilling by doubling the drilling speed and extending the drillbit lifetime in hard and abrasive formations. The test was performed on April 25, 2023, in partnership with Nabors Industries Ltd. at its technology center in Houston. Integrating the innovative drilling tools of GA Drilling into Nabors' automated drilling operations is expected to accelerate field commercialization and eliminate traditional economic barriers to deep geothermal projects. This should expand global access to geothermal energy.

Geothermal power plants have delivered 24/7 energy for decades but only in specific tectonically active areas like California or Iceland, where only relatively shallow drilling is required. In all other places, conventional technologies have until now not allowed for cost-efficient drilling. GA Drilling is launching breakthrough technologies to gradually unlock this massive fossil-free baseload energy source anywhere needed, delivering terawatts of clean energy from unprecedented depths globally and unlocking the commercial opportunity of geothermal energy.

ANCHORBIT is a downhole walking system that prevents vibrations and improves stability when drilling with rotary systems in the hard and abrasive formations commonly encountered in deep and hot geothermal projects. In these conditions, ANCHORBIT should double the rate of penetration and bit lifetime since the tool allows for the stabilization of the bit in the wellbore and thus applies more weight to the bit. Currently, drilling in such conditions is accompanied by vibrations, a low rate of penetration, and frequent replacement of bits.

ANCHORBIT is designed to improve drilling economics and make more geothermal projects economically feasible. It is a plug-and-play solution with conventional rotary drilling, which will enable immediate commercialization after the final development cycle. It is also designed to be part of the GA Drilling's PLASMABIT technology.

GA Drilling | *www.gadrilling.com*

Tool Search Features

To help lineworkers to find whatever they need, Huskie Tools has launched an easy-to-navigate website featuring its Product Finder and a newly engineered and customized Die Finder. The manufacturer, located just outside of Chicago, Illinois, provides a complete line of products for utility lineworkers who work on aerial or underground, transmission and substation applications.

As part of its product offering, it continues to engineer tool solutions for crimping, cutting, bending, and pulling for the line trade.

The Huskie Tools Die Finder allows customers to input any information they have on the die that they are looking for, click search, and instantly see all the appropriate available dies that fit their needs. Armed with that information, they can contact their local tool supplier and order exactly what they need, knowing they have all the necessary info to get the order placed and to get the order right. This specific online tool for die selection mimics the same process that Huskie uses for its product finder module. S

Not only is there a Die Finder and a Product Finder, but stage two of this process will marry them both together so the customer can not only find the correct dies but it will also offer up new tool technology available that works with the specific searched dies. .

Huskie Tools | *www.huskietools.com*

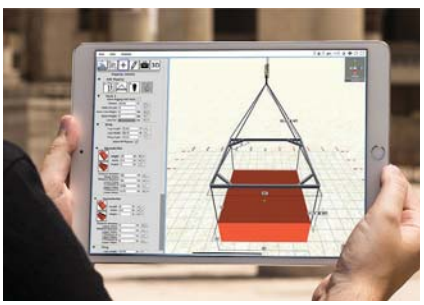
Adjustable Belt

Buckingham Manufacturing Co. Inc. has launched the Adjustable TriFit Short Back Belt. The fully adjustable belt is now equipped with three forms of adjustment. The patent-pending belt allows the user to easily adjust both the upper and lower sets of D-rings and offers an adjustable man-rated upper belt strap. The adjustable belt strap allows for more adjustment on the lower end of the adjustment range to fit a wider variety of body styles. This is especially useful for smaller-waisted users, according to the company.

Buckingham Manufacturing Co. Inc. | *https://buckinghammfg.com*

Rigging Plan App

A1A Software LLC, developer of 3D Lift Plan, has released a new application-based tool for anyone who needs to create rigging plans. The stand-alone application, available in the A1A Product Suite, provides detailed documentation for pre-lift planning, while also being easy to use on the go for planning in the field.



Rigging Designer is pre-loaded with options for 3D equipment, such as mobile cranes, excavators, forklifts, overhead cranes, or gantries. A library of more than 1,300 3D objects includes common loads lifted in construction and industrial applications and common buildings. Users can also create their own object to be lifted by entering the dimensions.

To create a rigging plan, simply input the center of gravity, pick points, hitch type, sling type and lengths, and other gear such as lifting beams, spreader frames, snatch blocks, or swivels. Rigging Designer will calculate sling angles and dimensions of rigging gear.

Rigging Designer is recommended for use with a tablet or desktop computer. It features easy-to-use drag-and-drop functionality and mirror/duplicate settings. Users can add notes regarding the lifting equipment to be used. Print your plan for use by rigging crews and field personnel, or create digital records that can be imported into the full version of 3D Lift Plan.

3D Lift Plan is a lift planning and crane selection software that can be used simulate a crane lift. Information such as crane assembly area, critical lifts, ground bearing pressure and crane mat selection, can all be documented.

A1A Software LLC | *https://www.a1asoftware.com/*

Data Analytics

Oracle has announced new capabilities to its Autonomous Data Warehouse, an autonomous database powered by machine learning and optimized for analytics workloads. The new innovations offer native multicloud capabilities, open standard-based data sharing, simplified data integration and analysis with a low-code-based tool, and ultra-fast enterprise storage at the same low cost as object storage.

Breaking through the proprietary and closed nature of traditional data warehouses and data lakes, the latest innovations address challenges faced by customers when analyzing siloed data across on-premises, cloud, and SaaS applications. They provide customers with query, manage, share, and scale capabilities, regardless of location.

The innovations also make it easier for customers to rethink their data warehouse and data lake architectures without having to choose between performance and cost. The new innovations include expansive multicloud functionality, providing secure access to object storage in AWS, Azure, and Google Cloud; live SQL connections to Azure SQL, PostgreSQL, Apache Hive, MongoDB, Snowflake, Amazon Redshift, and Azure Synapse; and pre-built connectors to ingest data from over 100 data sources.

Oracle's Autonomous Data Warehouse now includes query access to Apache Iceberg tables and integration with AWS Glue for retrieving data lake schema and metadata automatically. Additionally, the innovations provide customers with low-code-based Oracle Autonomous Database Data Studio, an intuitive self-service cloud console for analysts and data scientists to load, transform, and analyze data without relying on IT. A Google Sheets add-on is now part of Oracle Autonomous Data Warehouse in addition to the already available Microsoft Excel add-in.

The company has also implemented the industry-standard, open-source Delta Sharing protocol, enabling customers to securely share data with anyone using any application or service that supports the protocol. This approach eliminates the use of stale data and inaccurate results, improving business decisions.

Oracle | *www.oracle.com*

Composite Poles

Creative Composites Group (CCG), a domestic manufacturer of Fiber Reinforced Polymer (FRP) composites, has announced that its StormStrong utility pole offering has achieved a cradle-to-gate Environmental Product Declaration (EPD) from BRE Global, a third-party, international system that compares and verifies information about the lifecycle environmental impact of products and services.

Parameters of the EPD include primary energy use as well as resource use, including materials, fuels and water. StormStrong composite utility poles are lightweight, designed for grid hardening and are engineered for the current and future sustainability requirements of the utility industry, containing no chemicals or additives that can harm humans or the environment.

As many hazardous chemicals needed to preserve wood utility poles are being banned, composites offer a solution that does not leach chemicals and that extends the sustainability of the product. Additionally, pole-quality wood shortages continue to be a factor and prohibit the ability to build out the grid. And, with steel poles, the associated weight contributes to added transportation needs, in turn adding to emissions.

Creative Composites Group | *www.creativecompositesgroup.com*

Battery Storage Integration

Amprion and E.ON have developed a solution called the decentralized grid booster, which integrates modular battery storage systems into E.ON's distribution grid. This concept improves grid stability, saves costs, and will be first implemented in Bavarian Swabia by LEW Verteilnetz, a regional grid operator within the E.ON Group.

Grid boosters are large battery storage units that quickly respond to disturbances in the transmission grid, preventing overloads and subsequent damages. With the ability to deliver power within seconds, grid boosters eliminate the need for costly preemptive redispatch measures.

The decentralized grid booster employs smaller modular battery storage systems at the distribution grid level, reducing connection costs, increasing availability, and improving flexibility. These modular components can be implemented more efficiently and have minimal environmental impact. By reducing the need for grid interventions, the grid booster enhances overall system efficiency. The decentralized modules have a combined capacity of nearly 250 MW.

Amprion | *www.amprion.net*

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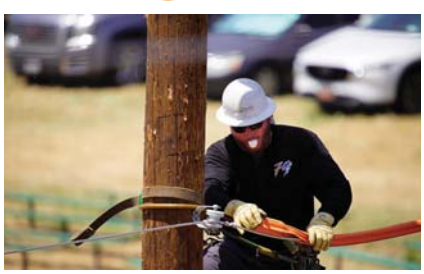
#LinemansRodeo In the pole climb event, competitors show off their smooth-safe-speed. They climb to the top of a pole, put an egg in their mouth and then back down attempting not to crack it. Wow!



Apprentice of the Year Spotlight

Meet Justin Johnson, a Journeyman Lineman who defied his fear of heights to pursue an extraordinary career. From playing football to a managerial role, Justin's journey led him to the power lines of San Diego County. Recognized as one of the 2022 @IBEW465 "Apprentices of the Year," he's proven that hard work and determination pay off.

NV Energy

NV Energy employees donated more than 70 Lego sets for kids in northern Nevada during the annual Lego drive benefiting The Children's Cabinet.

Lisa Grow
President & CEO of Idaho Power and IDACORP

I often say that Idaho Power runs (safely of course!) toward trouble. Last night's storm response certainly put that on display. I am so proud of everyone at Idaho Power — those you see and those behind the scenes — who banded together to get the tough work done for our customers. Together, they restored over 100 outages overnight.

Diane Leopold
Chief Operating Officer at Dominion Energy

50 going on 80! That is the focus at Surry, the first U.S. nuclear power station to be licensed for 80 years. Work is already well underway to replace, modernize and protect. This latest refueling outage was no exception.

President, New England at National Grid

I was proud to be part of such a great National Grid team participating in Boston Pride for the People this weekend. Over almost two miles of marching, we were buoyed by the joyful spirit of thousands of our friends and neighbors we are privileged to serve across Massachusetts

AD INDEX

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Collaboration Between Trucking and Utilities Is A Must

Whether to meet corporate sustainability goals or because of governmental regulations, many trucking fleets are in the process of adding battery electric vehicles to their operations. In fact, they are moving from having one to two trucks to scaling up to adding larger quantities of vehicles at a time when EV manufacturers are ramping up production to meet the growing need for electric trucks.

However, moving from one or two trucks to 15 or more brings with it some challenges mostly surrounding the charging of those vehicles. Most fleet depots do not have enough electric capacity on site to charge large numbers of EVs, and therefore they will need to have charging infrastructure added to their site if they want to have large deployments of EVs.

Run on Less - Electric DEPOT. Photo courtesy of NACFE.

Doing so will require collaboration with local utilities and that collaboration needs to begin well before the first EV is ordered by the fleet. Typically, most fleets have very little contact with their local utilities and may not even know the proper person to speak with about the process of building out infrastructure for EVs. Conversely, not every utility is well-versed about the realities of the trucking industry and may not understand their charging needs.

That is why it is important that these two industries — which have some similarities but are also different — need to spend time getting to know each other. One possible good collaboration I see is between state utility commissions and state trucking associations. The state utility commissions can educate trucking companies about their plans for build outs, can explain rate structures and things like demand charges and can review the basic process needed to build an EV infrastructure. The state trucking associations can be a great resource for utilities trying to understand the realities of operating a trucking company and the obstacles fleets face on their road to electrification.

Trucking is not a homogeneous industry. In other words, no two fleets are alike. What they haul, where they haul it, how long their routes are, and the type of equipment they have varies widely. Therefore, their electric power needs and hours available to charge their electric trucks will vary widely based on their individual operating conditions.

A good way to begin understanding the nature of the trucking industry is to follow The North American Council for Freight Efficiency's (NACFE) Run on Less – Electric DEPOT (RoL-E DEPOT), a three-week event that is focusing on the biggest challenges to scaling the deployment of electric vehicles. The event will feature eight fleet depots with 15+ Class 3 to 8 battery electric vehicles. The transition to electric trucks is about much more than just the trucks themselves and the event is not only highlighting the vehicles but also charging, infrastructure, grid capacity, resilience, etc. One of the goals of the Run is to showcase the benefits of collaboration between fleets and utilities now and in the future.

I have had the honor of attending and/or speaking at utility industry conferences and events. This has allowed me to gain a better understanding of the varies business models utilities operate under and that like the trucking industry each utility has its own unique operating structure. Since many fleets have operations in multiple regions of the country, it can be frustrating for fleet managers to grasp that working with a utility in one part of their market is very different from working with a utility in a different part of their market.

This is where collaboration and communication can play a big role in easing frustration on both sides.

It is important for utilities to understand that the trucking industry is relationship oriented. Truck fleets know their suppliers and suppliers know a great deal about the fleet managers they work with. This extends to not only knowing about their operational challenges but also knowing about their families, recreational activities they like, etc. These relationships are deep, allowing for an open exchange of information and result in creative problem solving.

Fleets and utilities need to develop these deep relationships, but that will not happen overnight. There is a need for conversations between fleets and utilities to start now so that relationships can begin to develop and the two groups can build trust in each other.

I encourage utility company executives to consider attending trucking industry events in their area to begin to get to know fleets. Events sponsored by state trucking associations are a good place to start. The American Trucking Associations has a listing of state trucking associations that can be a good resource to utilities looking for local trucking industry events to attend.

The trucking industry and the utility industry have to work together to gain a better understanding of each other because making assumptions that one trucking company is just like another or one utility is just like another can cause untold frustration. NACFE is here to help, and, in fact, we will be participating in an all-day workshop during this year's T&D World Live where we will bring together fleets and utilities to talk about battery electric trucks. We will also have a booth at the show where we will have live updates from RoL-E DEPOT. TDW

DAVE SCHALLER is director of industry engagement of the North American Council for Freight Efficiency.

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