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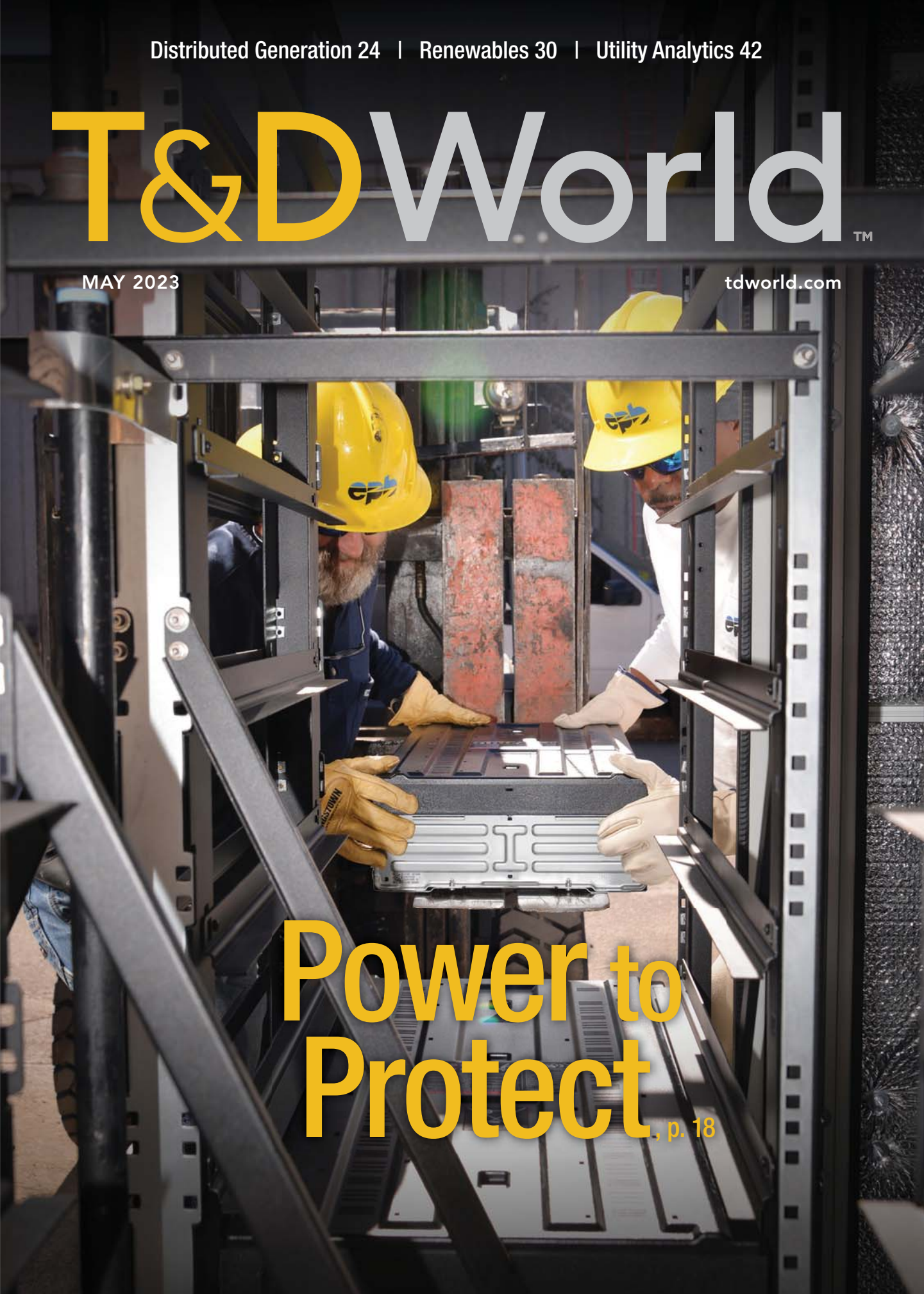

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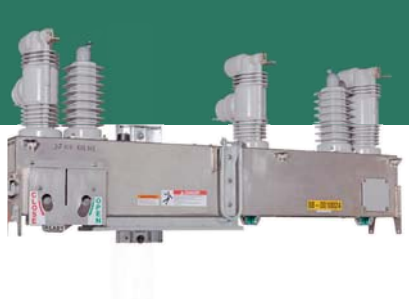

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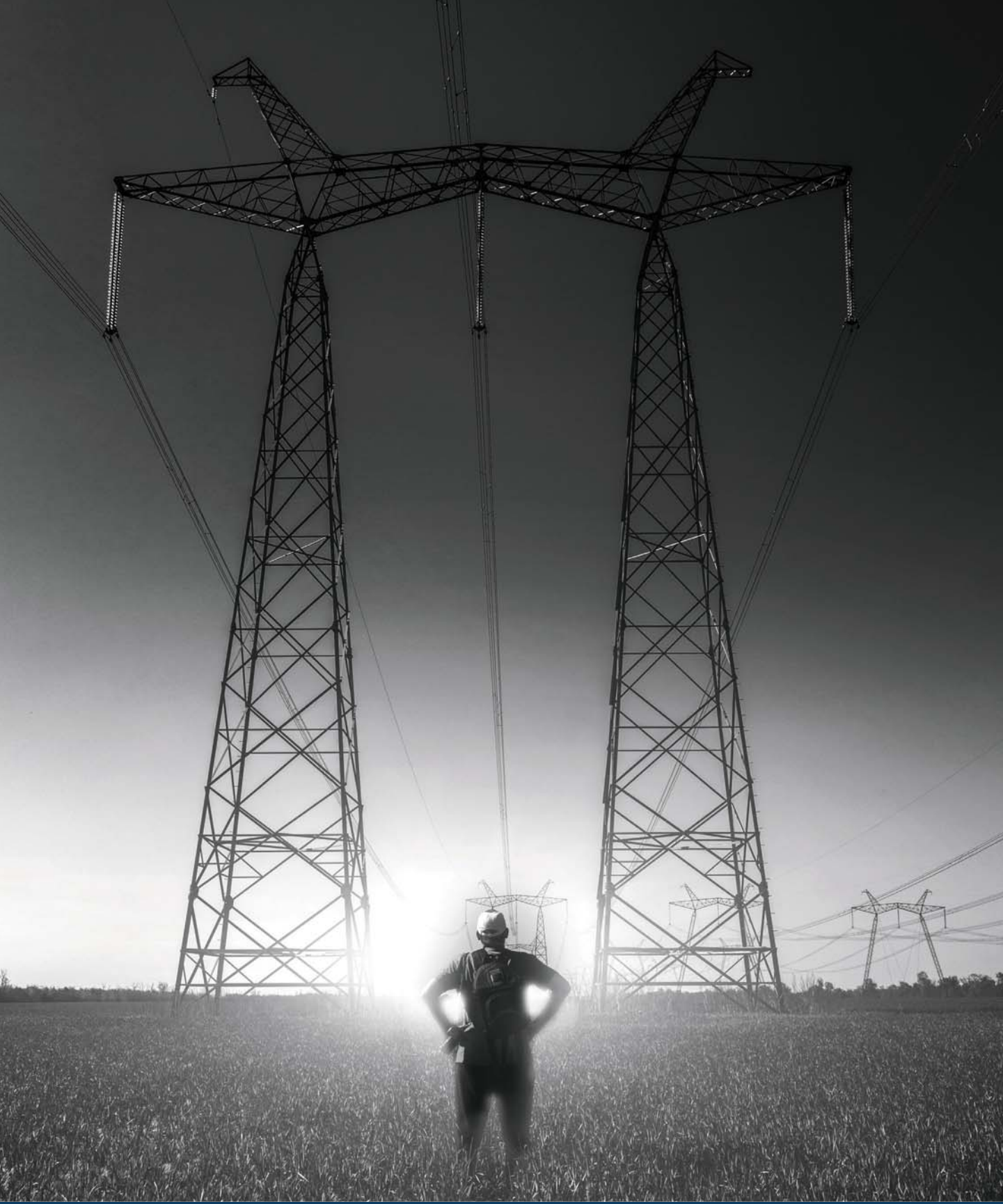

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T&D World (USPS Permit 795-660, ISSN 1087-0849 print, ISSN 2771-6651 online) is published monthly by Endeavor Business Media, LLC. 1233 Janesville Ave., Fort Atkinson, WI 53538. Periodical postage paid at Fort Atkinson, WI, and additional mailing offices. Canadian GST #R126431964.

POSTMASTER: Send address changes to *T&D World*, PO Box 3257, Northbrook, IL 60065-3257.

SUBSCRIPTIONS: Publisher reserves the right to reject non-qualified subscriptions. Subscription prices: U.S. ($137.50); Canada/Mexico ($170.00); All other countries ($210.00). All subscriptions are payable in U.S. funds.

Send subscription inquiries to *T&DWorld*, PO Box 3257, Northbrook, IL 60065-3257. Customer service can be reached toll-free at 877-382-9187 or at tdworld@omeda.com for magazine subscription assistance or questions.

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The Willingness to Share and Collaborate

In the past few weeks, I attended a couple of industry conferences where I heard utility experts discuss the many challenges they face due to the rapid pace of the energy transition. Most agree that there is an urgent need to innovate, and some even said that time is the enemy.

A common message among both events was that utilities must use the solutions that are available now with the understanding that new solutions will be added as they become available, and those solutions might or might not align with today's decisions. Flexibility and open minds are imperative. Some speakers said that utilities must continue to make long-range plans, especially those related to carbon reduction and vehicle electrification goals, but they should expect goals and plans to change. A couple of speakers pointed out that in many states, the carbon reduction goals that are in place today will likely be met before the deadlines. And, in relation to electric vehicles, they predicted that the forecasted adoption rate is going to be surpassed. In other words, the uptake of electric vehicles is going to occur much quicker than expected. If any of their predictions are correct, creating the future grid, one that will facilitate electrification preparation for the transition, could be even more urgent.

Although there are significant challenges, utilities have a great advantage. Unlike many industries, utilities are known for their willingness to share and collaborate with each other, as well as with solution providers. This type of cooperation and collaboration will be key to their success. As is common, at these events I recently attended, I heard numerous utility representatives discuss projects and processes they've developed to meet challenges and seize opportunities. They candidly talked about successes, as well as failures and frustrations. They answered questions and offered advice aimed at helping other utilities avoid making the same mistakes or succeed by learning from their success.

Face to Face

T&D World has been an outlet for information sharing among utilities for decades and we recognize that face-to-face events are a great way for utilities to share their stories and learn from one another. For that reason, we are planning our second annual T&D World Conference and Exhibition. With the help of an advisory board of industry experts, most representing utilities, and grid owners/operators, we've created a stellar conference program featuring more than 60 utility speakers who represent 30 different utilities. On Sept. 12–14, in Sacramento, California, these experts will share their experiences and expertise with our conference attendees. The program includes 42 conference sessions including a keynote, three plenary sessions, three super sessions and at least 36 breakout sessions that will include technical presentations, panel discussions and case studies. We're thrilled to have confirmed speakers from utilities of all sizes from across North America, as well as India, Brazil and Germany. In addition, we're offering three pre-conference educational courses and technical tours. The T&D World Conference schedule and session details, which cover grid edge technologies, renewable energy and DER integration, black sky hazards, wildfire mitigation, data analytics, digitalization, electrification and infrastructure expansion, are being added to our event website daily.

I'm also happy to share that we're expanding on one of the highlights of last year's event — the Commercial Electric Vehicle Infrastructure Conference (CEVIC). The CEVIC is designed to bring electric utilities, fleet owners, manufacturers of medium- and heavy-duty vehicles, manufacturers of chargers, industry association representatives and regulators together to discuss how they can collaborate to ensure a smooth and timely transition to electric fleets. *T&D World* is partnering with Fleet Owner magazine, one of our sister publications, and the North American Council for Fleet Efficiency (NACFE) to create a program that will allow for and encourage much needed conversation.

We're excited about this live event and are happy to offer it, but it's important to remember that it is just another outlet for information sharing. *T&D World* has been fortunate to have the help of many contributors and industry experts from around the world who for years have been happy to provide great content and share their experiences and knowledge. Because of these individuals and the many editors who have worked on the magazine throughout its history, *T&D World* has been able to provide the latest industry information and utility stories for 75 years.

A Tribute

Gerry George, *T&D World's* International Editor of nearly 27 years was one of the individuals who helped us gather content. Gerry worked with international utilities to obtain case study articles, and also represented *T&D World* at international trade shows, wrote show reports and sent along international news. Gerry was the "world" in *T&D World*. I'm sad to announce that Gerry passed away on March 28 at his home in the UK. I never had the pleasure of meeting Gerry in person, but others on the *T&D World* team knew him well. They all agree that Gerry was a consummate English gentleman. It seems that the only thing he loved more than the electric utility industry was his family. It was not unusual for his wife Pat to accompany him to events, and she even helped him with *T&D World* editorial work throughout his years with us. Gerry was known for sending formal and eloquent Christmas wishes to the staff each year, and each person who worked closely with him seems to have a favorite story about Gerry. He will be greatly missed.

We will continue to cover global transmission and distribution to ensure that we live up to our name and to carry on Gerry's legacy. TDW


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Advancing the Road to Net Zero at Two Deliberate Speeds

LOS ANGELES—The days crawl by but the years fly. This old saying alludes to the stunning rapidity of life passing by even it seems to move slow, but it also fits for a moment that is not seized strongly enough to impact the future in a critical way. One such moment, which can be easily lost, is the opportunity to create a clean energy ecosystem for decades to come, if only we as a community of human beings could fully commit to the desired Net Zero path.

Shouldn't be a problem these days, right? The Biden Administration pushed through passage of two sweeping pieces of legislation: The Infrastructure Investment and Jobs Act, as well as the Inflation Reduction Act creating access to more than $1 trillion in energy investment incentives and credits, and last year total global spending on clean energy accelerated to a record $1.1 trillion.

But all the money won't another minute buy, to quote "Dust in the Wind." More than 90% of companies with Net Zero commitments won't make those goals by 2050 at their current paces, according to professional services giant Accenture.

At the recent Accenture International Utilities and Energy Conference in Los Angeles, this optimistic sense of present-day satisfaction and yet creeping fear of losing momentum was highlighted front and center by a host of high-level industry leaders who applauded progress made but warned of digression around the corner if leaders lose focus or give up hope.

"We find ourselves at a critical moment," Scott Tinkler, Global Utilities lead and a senior managing eirector at Accenture. "This past year proves we can move faster than ever in a compressed timeframe."

The deployment of installed wind, solar and battery storage is growing at an all-time pace. Demonstration work into hydrogen and its carbon-free benefits for baseload power is yielding significant dividends and learnings that will guide upcoming projects, while even nuclear is gaining a rebound of sorts. Clean energy investment is finally achieving parity with fossil-fuel project spending.

And yet the treadmill is moving faster than the runner's speed, with extreme weather outcomes getting worse and no future certainty of political support down the road, at least in the U.S.

Scott Drury, CEO of utility Southern California Gas quoted both Clash punk rocker Joe Strummer and Mahatma Gandi, respectively, in saying "the future is unwritten" and "the future depends on what you do today." In other words, don't take the energy transition progress so far for granted.

"The outcome is not preordained," Drury noted. "If we approach it with innovation, collaboration and tenacity, we can make it."

The pace of the energy transition is perhaps both exilerating and exhausting at the same time. Utilities and the commercial and industrial sectors desperately need to move faster, while also maintaining a steady pace of future investment, research and development in a myriad of decarbonization strategies, from renewables to efficiency to demand response.

"We must operate at two different speeds: the sprint and the marathon," Tinkler pointed out. "The sprint means embracing digital technology and moving in a compressed transformation," he added. "Marathon speed is bringing order to chaos and making it an efficient, affordable transition. If we operate only at a sprint, we leave value on the table. If it's only at marathon speed, we miss most of the key dates or targets."

The United Nations estimates that reaching Net Zero carbon emissions by 2050 helps to limit global warming to only 1.5-degrees Celsius above pre-industrial levels. Even that seemingly harmless increase actually causes disastrious weather outcomes, rising sea levels and completely unknown other atmospheric reactions.

Beyond the visual allure of silicon-coated solar panels or lithium supply chains for battery storage, there is a less sparkly but certainly preeminent place for data analytics and control technologies. The balance between multiple energy resources and power resiliency lies in the digital transformation, the speakers at Accenture's IUEC agreed.

"There is no energy transition without digital," Ana Paula Marques, CEO of EDP Global Generation Platform and EDP Spain, said in a panel that included leaders from Xcel Energy, Enel North America and Accenture. "Digital is both an accelerator and enabler."

In a day that inspired quotations from notables as varied as a punk rocker, world-renowned peace activist and champions of "purpose-driven work," Tinkler found voice in the words of fictional scientist and astronaut Mark Watney, played by Matt Damon in the popular film "The Martian."

In the firm, Watney is stranded on the red planet to face almost certain death. However, he "sprints" to develop immediate life-saving strategies and concurrently forms a sustainable plan for long-term engagement that eventually reveals his survival to ground control on earth.

When Watney is rescued and returns home a hero, one of his students asks how he was able to hang in there and find the will to survive. "You just begin," Watney says. "And if you solve enough problems, you get to come home."

The destination for the energy industry is Net Zero. Anything short of that will be viewed by future generations as failure, but it must be deliberate, sustained and patient. It's done as a sprint and marathon at the same time, making present successes as benchmarks and committing to long-term giant leaps forward while staying alert and adaptable to what the science reveals in the here and now.

"We put in the work, we do the math," Tinkler said. "We solve one problem and then the next and then the next." TDW

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A Smarter Grid With AI

A couple new artificial intelligence (AI)-powered applications were in the latest upgrade for my computer's photographic suite. I use one to restore ancient photos of long-gone ancestors I found fading away in an old family album. The other colorizes those old photos, making them seem a little more natural. I also found an AI app that animates portraits. I can't wait to try it. I know I'm a techno-junkie, but I do find all the advancements fascinating.

Currently that's probably not the best thing to admit to, especially with all of the mainstream media's attention on "AI." The most recent upset came about with those latest AI apps that can write and take tests. All you have to do is give the app a subject, and it will deliver written works on demand. Some of the examples I have seen look pretty good. There is, however, a great deal of critical pushback from many different sectors predicting dire consequences.

Critics warned that people will lose their ability to write, and students will cheat their way through school. It reminds me of when I was an undergraduate and the pocket scientific calculator was introduced. Critics warned that people would lose their ability to do math and students would cheat their way through school. Guess what, my instructors used the calculators too.

That resulted in my homework and exams getting a heck of a lot harder. My professors expected more from their students. Test questions became more complicated, and we became more efficient with our test time. I'd be willing to bet that critics of the time said similar things when the abacus was introduced!

Challenged Exponentially

I do agree that the growing use of AI is something to be careful about, but it's a tool and all tools have to be used correctly. Listening to the hue and cry about the dangers of AI sounded like the "Exponentially Challenged" subject discussed in the March, 2023 "Charging Ahead" editorial (https://tdworld.com/21259377). There is no denying it, the deployment of AI apps is a game changer. Like all technological advancements there are going to be pros and cons, but it's just part of the process.

Consider the smart meter. It was met with some resistance, but has proven its worth and now another technological improvement is happening. Smart meters don't have computing power, but what if they did? That's where AI comes into play. The customer's side of the meter has a lot of technology being deployed on it.

Guillaume/Getty Images

Things like DER (distributed energy resources), EV (electric vehicle) chargers, smart appliances, and other devices are installed there. Recently, Bloomberg announced that Utilidata and NVIDIA have developed a custom module that brings AI to the customer's meter. It's a first-generation AI platform installed next to the meter. It was field tested last year in Lake Placid at New York Public Power Community. Bloomberg said the companies are ready to deliver this latest application.

Another AI application is improving EV chargers. These devices are being deployed in growing numbers and AI charging management systems are making chargers more efficient. Hitachi Energy has developed intelligent hardware and sophisticated software for EV fleets using AI technology to manage EV fleet charging in real-time. This aids the fleet owners and the utilities when it comes to balancing load and source requirements more efficiently.

AI is also starting to impact the world of virtual power plants (VPP) as it is integrated into complex VPP real-time data management schemes. To be successful VPPs need to be able to utilize all the DERs available, making them all act as one generation plant and that's where AI comes in. VPP systems with AI monitor the grid and predict how much power is needed and matches the aggregated generation to that prediction. Utilities and aggregators are taking advantage of these VPP applications from suppliers such as GE, Hitachi Energy, Siemens Energy, and others.

There are many other examples of AI being integrated into smart grid equipment and operating systems, but you get the point. As the power grid gets more complex, AI is becoming an integral part. It's a good bet that there are going to be some bumps along the road, but one thing is certain. Businesses not taking advantage of sophisticated AI enhanced tools will place themselves at a tremendous disadvantage over those who are using them. It's going to be uncomfortable, perhaps disruptive, but exciting! TDW

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The Power Grid's Gas Problem

When it comes to combating global climate change, decarbonization is only part of the challenge.

Did you know that roughly 80% of all SF_6 (sulfur hexafluoride) gas produced worldwide is used by the electric power industry? That headline caught my attention recently and it was followed by another one equally surprising. The largest source of emission (i.e., leaks) of SF_6 comes from the power industry using it as an electrical insulator in high-voltage equipment. Tying these facts together helps explain why there is a growing movement to remove SF_6 from the electrical grid.

SF gas-free Blue GIS in Norwegian substation. Courtesy of Siemens Energy.

The message has been getting across and a great deal of research and development (R&D) has produced viable alternatives for SF_6 in switchgear and other devices. It has taken time, but there are now environmentally friendly replacements for SF_6 available to the industry. Granted SF_6 gas has been a mainstay in electric power grid when it comes to an insulating medium, but that is changing. Slowly the power delivery industry is moving away from this environmentally harmful insulation medium.

SF_6 is a synthetic gas with a fantastic electrical insulating quality. It has been used in switchgear, instrument transformers, and other electrical devices for many decades. It also has tremendous current interruption capabilities, and it displays incredible arc breaking properties. There is, however, more to the story.

Adding to Global Warming

According to the EPA (US Environmental Protection Agency) SF_6 has been identified as the most harmful and longest lasting greenhouse gas produced by human activity. It's an F-gas. F-gases are synthetic fluorinated gases that have proven to be harmful to the environment. There are many greenhouse gases. How does all of this relate to the power grid's use of SF_6?

EPA's report addresses that, explaining that there are several properties giving SF_6 such a high profile when it comes to damaging the environment. The emissions have a 3,200 year life span, which makes it extremely long-lived. In other words, any SF_6 emissions accumulation does not degrade. Another of SF_6's worrisome properties is its global warming potential (GWP).

What is a GWP rating? It's an indexing scale based on a number of factors using carbon dioxide (CO_2) as the reference greenhouse gas. Basically the GWP for a greenhouse gas is the amount of heat absorbed by 1 ton of emissions from that gas in the atmosphere compared to 1 ton of the reference gas (i.e., CO_2) during a specific time frame.

The period of time being used for GWP calculation is 100 years. 1 ton of CO_2 has a GWP value of 1 (the reference point), and 1 ton of SF_6 has a GWP value of 23,500. With that GWP rating, SF_6 is 23,500 times more potent than CO_2 when it comes to SF_6's effect on the environment. Or 1 ton of SF6 does as much damage to the atmosphere as 23,500 tons of CO_2.

Alternatives

SF_6 gas is very efficient when it comes to trapping infrared radiation. A relatively small amount of it can have a significant impact on global climate change that lasts for centuries. Adding all of these data points together explains the reason for the headlines that started this discussion, and the grow-

ing support for banning F-gases. But it's not all gloom and doom! There are several SF_6 alternatives available. These alternatives include a purified air compound, non-synthetic mixtures, and gases from the PFAS (per- and polyfluoroalkyl substances) family.

Each of these alternatives have economic and/or environmental considerations, and like all technological advancements users should understand the pros and cons involved with each of them. There are some environmental concerns with the PFAS gases, which are being studied by several regulatory bodies, but that may be a moot point soon. One of the major suppliers of these gases announced last year they were discontinuing their production of PFAS in 2025.

Manufactures like GE, Hitachi Energy, Mitsubishi, Schneider Electric Siemens Energy, and Toshiba to name a few have taken advantage of the R&D and are now offering non-SF_6 switchgear. It's encouraging that there are a number of compounds that are viable as replacement alternatives for SF_6 gas, but it's somewhat complicated.

Digging Deeper

With that in mind, "Charging Ahead" spoke with Dr. Mark Kuschel, head of International Standardization for Grid Technologies at Siemens Energy to get a better understanding of the global picture. Kuschel began the discussion saying, "SF_6 is not the future, it's the past! SF_6 has been the standard insulation solution used in switchgear worldwide since the 1960s, but this has to change. As the global consumption of electricity increases, so does the demand for switchgear. Those switchgear must have an environmentally friendly insulation medium. Now is exactly the right time for the electric power industry to move to F-gas-free insulation technology."

Kuschel explained, "In March, 2023, the European Parliament's committee on Environment, Public Health, and Food Safety (ENVI) voted to accelerate the complete phase-out of SF_6 and the other fluorinated gases. For electrical apparatus, it's a staged approach. The ban would take effect on all voltage levels, in high-voltage switchgears with 145 kV (kilo volt) and below and a current capacity of 50 kA (kilo ampere) and below by January 1, 2028. Voltage levels above 145 kV and above 50 kA by January 1, 2031, but this is not an unexpected event."

"Siemens Energy started working on an F-gas-free alternative over ten years ago, and has developed a technology using purified air that we call clean air. Clean air is a mixture of 80% N_2 (nitrogen) and 20% O_2 (oxygen), and has a GWP of zero. Worldwide, various manufacturers are using the clean air approach and alternative insulations based on mixtures of CO_2 and O_2. These have been referred to as natural origin gases with a GWP less than one." Dr. Kuschel said.

He continued, "When the industry moved from oil to SF_6 there was some pushback because it was a new process. There wasn't any experience with the new technology, and it took time to make sure SF_6 technology was dependable. Now utilities have to reach the same point of acceptance for clean air technology. To date, Siemens Energy has delivered more than 3,000 units from its F-gas-free Blue Portfolio with some being in service for over five years. The field experience has been positive, the technology has proven to be dependable. Siemens Energy is committed to being F-gas-free and aims to sell only F-gas-free high-voltage switching technology worldwide starting in 2030 at the latest."

Give & Take

On the global regulatory front, there is a mixed bag of guidelines, rules, and regulations. In the US, the EPA has monitoring and emissions requirements for F-gases, but bans are being proposed by individual states. The most ambitious comes from the California Air Resource Board (CARB). Last year the CARB's regulations took effect for the reduction of SF_6 in gas insulated equipment.

These phase-out dates are much like those from ENVI. They are based on voltage levels and current capacities with the low voltages coming first and working up to the higher levels. The phase-out limits start becoming effective Jan. 1, 2025 and will be complete by 2033.

With the ENVI ban on F-gases in switchgear, the Norwegian distribution system operator Fagne announced they have signed an agreement with Siemens Energy to supply climate-neutral Blue portfolio switchgear. The switchgear will use synthetic air (Clean Air) in conjunction with vacuum-switching technology at their substations in Sunnhordland and Haugalandet, Norway.

Last year, European transmission system operator TenneT placed an order with Hitachi Energy for three bays of Hitachi Energy's SF_6-free EconiQ 420 kV gas-insulated switchgear (GIS). TenneT said the GIS uses technology that eliminates SF_6. The project is expected to be completed in 2026.

TEPCO Power Grid in Japan awarded a contract to Toshiba Energy Systems & Solution Corp. for a 72 kV GIS at Fuchu substation. The GIS uses an insulating medium of nitrogen and oxygen (synthetic air), which is completely SF_6 free. The project is expected to be completed in 2023.

Entergy Mississippi recently installed a 123 kV Siemens Energy Blue circuit breaker at one of its substations in Vicksburg as part of its effort to achieve net-zero carbon emissions by 2050. The Blue circuit breaker is a replacement for a high-voltage oil circuit breaker. The Blue circuit breaker uses clean air in combination with a vacuum interrupter to provide an SF_6-free switchgear.

Those are only a few of the examples available illustrating how utilities and grid operators are moving from SF_6-insulated equipment to F-gas-free switchgears, but there is another issue. With 80% of the world's SF_6 gas in the power grid's equipment, it's important to curtail new SF_6 additions. Authorities say it's equally important to develop the technology to stop leaks and prevent emissions of SF_6 from existing equipment. This is another important step in addressing the SF_6 issues facing the power delivery industry. It's going to be challenging, but it's manageable. That's what makes following technological trends so fascinating! TDW

NATIONAL GRID ENERGIZES T-PYLONS

National Grid has successfully energized 36 of the world's first T-pylons between Bridgwater and Loxton in Somerset. The new shaped pylons have been constructed as part of the £900 million Hinkley Connection Project, a new 57 km high-voltage electricity line that will connect six million homes and businesses to new sources of home grown, low carbon energy and help the UK to meet its net zero by 2050 target.

High-voltage electricity – up to 400,000 volts – is now passing through the T-pylons, a newly constructed electricity substation at Sandford and 8.km of underground cables through the Mendip Hills Area of Outstanding Natural Beauty. A further 80 T-pylons will be completed and energised by 2024.

Construction of the first T-pylons began in September 2021, with all the conductors or wires that transmit the energy between Bridgwater and Loxton installed by March 2022. The conductors are now energised and transporting electricity around the National Grid's electricity network.

The T-pylon design, the first major UK redesign since 1927, has a single pole and cross shaped arms, and is around a third shorter than traditional high-voltage pylon design with a smaller ground footprint. The new design was selected from over 250 designs entered into an international competition run in 2011, organised by the Royal Institute of British Architects and government (the then Department of Energy and Climate Change). With a need for new energy infrastructure to enable progress towards net zero, the competition sought a new design to reduce impact on the local environment and surroundings.

Along with offshore routes, underground cabling and continued use of traditional lattice pylons, the new T-pylon design is a potential technology choice for future projects. Each new transmission network project is assessed on a case-by-case basis, with the technology used by National Grid based on planning policy and regulations set by Ofgem as well as engineering, environmental and cost considerations.

"The T-pylons are now reinforcing and strengthening the network in the South West and are ready for the connection of low carbon energy when Hinkley Point C starts generating," said Steven Haskayne, project director for National Grid. "This new design forms part of our significant investment in the network in England and Wales, adding capacity onto the grid to deliver low carbon electricity to millions of people across the UK to use for years to come, and helping the UK's journey toward net zero." ■

ABB INVESTING $40M IN NEW MEXICO CABLE PLANT

Executives of electrification and automation giant ABB have announced plans to build a cable products factory in New Mexico that will feed utilities' work to harden their grids.

Switzerland-headquartered ABB, which has its U.S. home base in Atlanta, will spend $40 million to add a 90,000-square-foot facility to its 40-acre campus in Albuquerque. The company also employs about 450 people there making and testing various products used in the energy sector. Plans call for the new plant to start production at some point next year and employ 55 people.

"Continuing to grow our US manufacturing operations and distribution network accelerates our ability to deliver high-demand electrical products our partners rely on to manage today's needs and prepare for tomorrow's energy demands," Matthias Heilmann, president of ABB Electrification's Installation Products division, said in a statement.

ABB's news adds to a wave of infrastructure investments as businesses and governments across the country look to accelerate the energy transition with the help of several pieces of legislation and buckets of incentives. Two other recently announced projects center on the wind energy sector:

- CS Wind America will on April 4 officially break ground on a 900,000-square-foot expansion of its Pueblo, Colorado, turbine tower plant. The addition will add 850 jobs at the site, which today employs about 650 people, over three phases.
- Leaders of Dallas-based Arcosa Inc. this month said they will invest about $60 million to convert a former plastics plant south of Albuquerque into a wind tower facility. The company will hire about 250 people there as it looks to fill roughly $750 million worth of orders it plans to deliver by 2028.

In their statement announcing the Albuquerque expansion, ABB officials said U.S. utilities are expected to install more than 75,000 miles of underground cables by 2040. Such investments are part of a broader energy-focused capital spending wave—from both the public and private sectors—catalyzed by the Inflation Reduction Act that Goldman Sachs analysts recently estimated will total $3 trillion by 2031. ■

XCEL FILES FOR TRANSMISSION LINE TO BRING MORE RENEWABLE ENERGY TO MINNESOTA

Xcel Energy applied for a Certificate of Need to build a new double-circuit 345-kilovolt (kV) transmission line to link at least 2,000 MW of new renewable energy to the grid — enough to power more than 1 million homes per year.

The proposed Minnesota Energy Connection transmission line will connect to new low-cost wind and solar energy that will replace the electricity currently generated at the Sherco power plant near Becker, reusing the plant's existing grid connections. The transmission project will also make progress for Minnesota's renewable energy goals.

The Department of Energy's recent needs study found that many regions of the U.S., including the Midwest, need more interconnection capacity with neighboring regions.

"Expanding our transmission infrastructure will pave the way for us to further reduce carbon emissions while delivering reliable and affordable electricity for our customers," said Michael Lamb, Xcel Energy's senior vice president, Transmission. "The Minnesota Energy Connection project will bring low-cost, renewable energy to millions of homes and businesses while reusing the important grid connections in central Minnesota that serve customers throughout the region."

The Minnesota Public Utilities Commission will now review Xcel Energy's proposal. The review process generally takes about one year and includes opportunities for input from customers, landowners and other key stakeholders.

While the certification process proceeds, Xcel Energy will also be working with local officials and landowners to identify potential route options for the project, which is expected to be between 160 and 180 miles long. Recently, project leaders held several public open houses in communities located along these route options to introduce the project and ask for feedback on how those options may affect land use issues in the area. The route options generally follow existing corridors, such as roads and existing transmission lines, when possible and aim to minimize impacts to land use, agricultural operations, natural resources, cultural and historical sites, and recreational areas.

Xcel Energy expects to file a Route Permit application with the Minnesota Public Utilities Commission in the fall of 2023, with a decision expected on the final route in late 2024. If both the Certificate of Need and Route Permit applications are approved, construction could begin in late 2025 and complete in 2028. The project and associated facilities, including technology to maintain voltage stability and reliability, are expected to represent an investment of over $1 billion in valuable infrastructure for the state and region, dependent on the final configuration and route selected, including voltage support technologies. ■

SOUTHERN CALIFORNIA EDISON DETAILS WILDFIRE STRATEGY

Southern California Edison has submitted its 2023-25 Wildfire Mitigation Plan to California's Office of Energy Infrastructure Safety. SCE has reduced the probability of wildfires associated with its utility equipment by 75%-80% since 2018. This is a significant improvement within a short period and the company's long-term public safety goals continue to be ambitious.

This year's plan details the company's strategy to continue grid hardening with covered conductor, also known as coated wire, and undergrounding more power lines in locations with the highest wildfire risk.

"We plan to further reduce the risk of wildfires and the impact of Public Safety Power Shutoff (PSPS) in this three-year phase of the WMP through grid hardening and customer care programs, building on the steady work we have completed over the past few years," said Steven Powell, president & CEO of SCE. "We understand the impact our customers in high fire risk areas have faced from the threat of wildfires and the PSPS program that prevents wildfires."

The 2023-25 plan includes a range of measures and key staples from previous plans. These include grid hardening primarily through the installation of covered conductor, enhanced vegetation management and advanced monitoring and alert systems to enhance situational awareness during dangerous weather events — all of which are vital to preventing ignitions from utility infrastructure. The plan further outlines the continued use of drones and helicopters to inspect more than 250,000 structures each year in high-risk areas to determine the potential need for repair or replacement.

"My city has been identified by the State of California as being in a high fire risk area. As such, I appreciate Southern California Edison's annual wildfire plan and its collaborative efforts toward reducing the threat of wildfires in our community," said City of Thousand Oaks Councilman Robert Engler. "Grid hardening, vegetation management and the deployment of resources like the Quick Reaction Force Helitankers are indicative of Edison's efforts to reduce fire exposure to cities like my own."

The plan prioritizes the installation of covered conductor in areas of higher wildfire or PSPS outage risk. SCE plans to install more than 2,850 additional miles of covered conductor during this plan period. By the end of 2025, the company expects to have replaced more than 7,200 miles, or about 75%, of overhead distribution power lines in high fire risk areas with covered conductor.

"Our 2023-25 plan builds on the significant progress of our wildfire mitigation program over the past four years — progress that is necessary as we witness the devastating effects of extreme weather," said Jill Anderson, executive vice president of Operations for SCE. "Our wildfire mitigation efforts will add resiliency to the electric system as we navigate a changing climate and move toward increased electrification in the economy."

SCE has identified specific high-risk areas across its service area where the undergrounding of power lines will be prioritized. The company is evaluating several hundred miles of power lines for undergrounding and plans to complete about 100 miles by 2025 to address the high risk presented by limited exit and entry points to communities, extreme potential consequences and other factors.

Over the next plan period, SCE will continue to focus and prioritize much of the company's efforts on vulnerable communities and those areas that have been impacted by PSPS, particularly for Access and Functional Needs customers. SCE will also evaluate and refine its stakeholder coordination and customer outreach programs based on feedback received from these stakeholders.

Lastly, SCE is expanding its partnership with fire agencies in its service area by moving to a year-round Quick Reaction Force (QRF) of aerial firefighting resources. The QRF includes helitankers, reconnaissance aircraft and equipment to bolster firefighting. These capabilities help to reduce a fire's consequences, provide service resilience to customers and protect electrical infrastructure. ■

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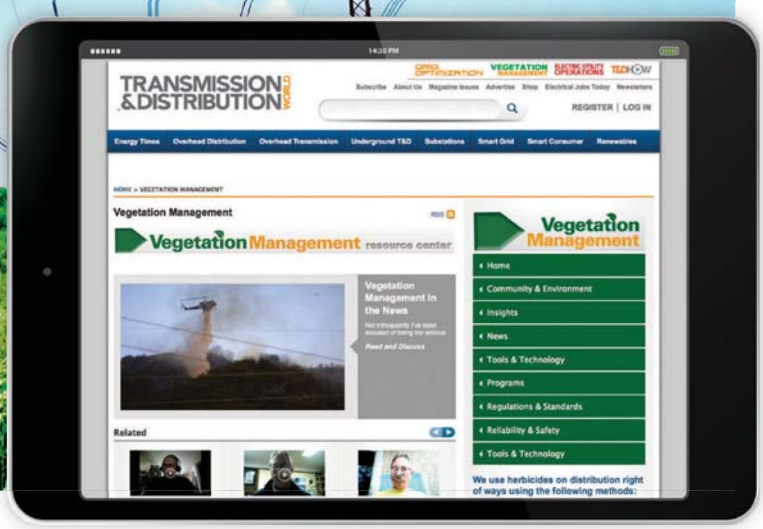

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CAUTION

Power to Protect During Emergencies

A microgrid at the Chattanooga police and fire administrative headquarters provides continuity and ensures a swift response to emergencies.

By **JIM GLASS** and **AARON WILLEY**, EPB of Chattanooga

Established in 1935 as an independent board of the City of Chattanooga, Tennessee, U.S, EPB provides energy and connectivity services to approximately 200,000 homes and businesses throughout its 600-sq-mile (1554-sq-km) service area. During the last decade, EPB and the city established a strong track record of working together closely to deploy smart city technologies, support economic development, close the digital divide and keep Chattanooga on the cutting edge through leading fiber-optic services and highly reliable energy.

In 2019, the City of Chattanooga launched a regional resiliency council to develop preparations for increasing severe weather events and grow the number of green projects under city management. At the same time, EPB was making plans to increase power reliability by investing in distributed energy resources (DERs) and reducing wholesale power costs. Soon after, tornadoes devastated neighborhoods east of the city on Easter 2020, placing more urgency on the need to provide continuity and ensure swift response if another emergency happened.

With the shared goals of protecting essential community assets, EPB and the city launched Power to Protect, a project focused on developing a microgrid at the Chattanooga Police Services Center and Fire Department administrative headquarters. These facilities operate 24/7/365, and include additional services such as a fire station, SWAT team, homicide, radio control center, city camera surveillance and other critical communication infrastructure.

Emergency Preparedness

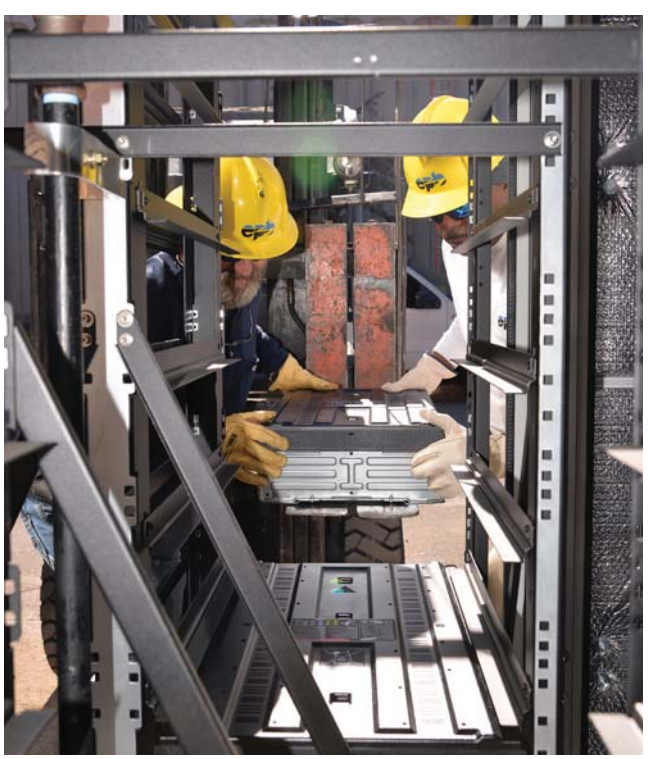
The city previously installed a large solar generation site for its wastewater treatment plant and wanted to expand its solar strategy using available roof space during a roof replacement at the Police Services Center, to ensure the location would maintain operations if electricity to the building were interrupted during a weather or other emergency. Backup

EPB's need for better emergency and electricity resilience was demonstrated during a tornado-producing thunderstorm that struck Easter 2020.

When the power goes out, communications systems fail and that can leave lives on the line. With public safety in the microgrid's footprint, we can help keep regional infrastructure, such as responder operations, functioning.

generators for the city's facilities were only sufficient to provide partial backup power for limited periods of time.

At a press conference to announce the project in spring 2021, Chattanooga Fire Department Chief Phil Hyman emphasized the critical need for Power to Protect as part of the city's emergency preparedness planning: "When disaster strikes and leaves entire communities in the dark without power, it provides such peace of mind to know that Chattanooga will have reliable energy for emergency response services. When the power goes out, communications systems fail and that can leave lives on the line. With public safety in the microgrid's footprint, we can help keep regional infrastructure, such as responder operations, functioning."



Cover: The city previously installed a large solar generation site for its wastewater treatment plant and wanted to expand its solar strategy using available roof space during a roof replacement at the Police Services Center, to ensure the location would maintain operations if electricity to the building were interrupted.

Smart Grid Technology

When planning began for the Power to Protect microgrid, one goal was to provide emergency power to multiple buildings that did not have emergency generators. EPB's existing electric grid already included multiple layers of automated restoration afforded by the smart grid.

Launched in 2009, EPB's smart grid has reduced outage minutes by up to 55% each year — making it one of the most reliable smart grids in the U.S. With such a dependable power grid, EPB focuses its microgrid development efforts on areas with lower power reliability or community assets that must continue to receive power under any circumstances.

EPB'S smart grid has 1200 smart switches, sensors and other devices on a 9000-mile (14,484-km) fiber-optic backbone to reroute power automatically when a disruption is detected. The police and fire microgrid campus is served by two sources to preserve power to the location. Given the reliability of the smart grid, the microgrid's design accounted for these initial connections first. If they failed, EPB system operators would remotely dispatch the microgrid from the distribution center, making the microgrid the third line of defense for this essential community asset — and only if the outage could not be resolved by the smart grid.

Investments And Benefits

Power to Protect began with an EPB evaluation of the site for maximum power requirements. To support needs during an outage that would necessitate transitioning to microgrid power, EPB sourced a new 500-kW/1100-kWh front-of-meter battery. Separately, the city invested in a 200-kW behind-the-meter diesel generator and 155 kW of solar panels.

The dual behind-the-meter and front-of-meter structure enables both entities to begin recouping their investments. In addition to continuing emergency services during an outage, the front-of-meter battery system enables EPB to shave peak load during extremely hot or cold weather, reducing peak demand charges and allowing EPB to recoup the investment in a faster manner. (EPB does not shave peak load if severe weather is in the forecast; batteries are charged to capacity, so they are prepared for an emergency.)

Behind-the-meter solar panels regularly reduce the amount of metered energy required for the building, lowering the city's EPB bill by roughly 20% monthly.

Operating Modes

During normal operations, the police and fire microgrid battery operates in grid-following mode, meaning it is connected to EPB's smart grid, which keeps the battery fully charged and ready when needed. If EPB's smart grid becomes unavailable and the automated restoration cannot resolve the outage, the microgrid transitions to island mode and the battery supplements what solar cannot produce, supports full load when no solar is available or charges when solar generation is greater than the site load.

The solar component of the microgrid follows the operations of the facility, whether it is operating on grid or battery. Solar generation also is given priority, so full output is used whenever possible and curtailed when output is greater than load.

The generator follows the same lead as solar and will turn on when the battery's state of charge drops to 10%. Conversely, the generator will stop charging when the battery reaches 90%.

The Challenges

Having enjoyed decades of working closely together, the city and EPB provided the foundation for Power to Protect to proceed smoothly with close communication and collaboration. Unfortunately, like most projects in the early 2020s, it soon fell captive to supply chain challenges that delayed the projected completion date from October 2021 to October 2022, despite the most diligent efforts of contractors and vendors. Nearly all major equipment was delayed, from generators to solar components, complicating the integration and timing to make them work interoperably.

Another complication, albeit anticipated, was the necessary logistical coordination with emergency services when planned outages were needed to make system reconfigurations and conduct tests. Paramount to all testing activities was the consideration that emergency responses could never be compromised. As several outages were necessary for swapping over the power, changing feeds and interconnecting equipment, EPB coordinated closely with the city to consolidate the necessary outages into the fewest number possible.

EPB and the city have a history of working together to deploy smart city technologies, support economic development and close the digital divide.

When microgrid testing began, the same care was taken to minimize operations. For example, EPB took care not to block exit routes that would hamper deployment of city fire and police resources to emergencies.

While not necessarily a challenge, EPB eliminated a risk to fire and police campus power by relocating an exposed power pole at the front of the building. The location is along a busy stretch of highway in an industrial part of town with

EPB's need for better emergency and electricity resilience was demonstrated during a tornado-producing thunderstorm that struck Easter 2020.

thousands of heavy trucks and equipment passing multiple times a day. To remove the potential for an outage caused by one of those vehicles striking the pole, EPB moved it to the rear of the facility, in an area with less traffic, decreasing the incidence of an outage related to a wreck and increasing the facility's power resiliency.

Managing Expectations

Testing began in September 2022 to validate the efficacy of the microgrid and was successfully completed in October 2022. Fortunately, as of this writing, there has not been an occasion to use it in a real-world response.

While the microgrid dramatically reduces the risk of losing power in a severe outage, it does not eliminate all power interruptions, in particular the momentary interruptions when transitioning from utility grid to microgrid. This is not a seamless transition; an outage, whether planned or unplanned, must happen before the microgrid can come on-line. This delay is to provide an opportunity for power to be restored by EPB's automated smart grid first. In a test situation, it takes three minutes to restore power using the microgrid; this time will vary depending on several factors during an emergency.

When operating, though, the microgrid can hold load 24/7/365 and provide enough energy for the fire and police departments to respond to the needs of Chattanooga indefinitely.

Next Steps

EPB continues to expand its microgrid and DER investments across its service region to improve power resiliency, support business continuity for critical community resources and reduce costs for customers through peak management. Current EPB DER investments have a combined capacity of 7850 kW ac, with another 6155 kW ac in development. Several projects are being planned now, particularly in rural areas that cannot be reached as quickly to resolve issues the smart grid cannot.

The city and EPB continue to maintain close contact on future projects that will increase the dependability of the power grid. TDW

JIM GLASS (*glassjb@epb.net*) is senior manager, smart grid development at EPB in Chattanooga, Tennessee. He is responsible for distribution automation, supervisory control and data acquisition, distribution management systems, demand management technology and distributed energy resources. Glass has a bachelor's degree in industrial engineering from the University of Tennessee and is a member of the Electrical Engineering Advisory Board at the University of Tennessee at Chattanooga, where he serves as an adjunct instructor.

AARON WILLEY (*willeyad@epb.net*) is planning engineer at EPB, with responsibility for evaluating the performance of its smart grid, including the development of strategies to improve reliability, reduce costs and improve customer service. Willey holds bachelor's and master's degrees in engineering technology from East Tennessee State University (ETSU) and is a past member of the ETSU college of engineering and technology Industry Advisory Board.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Agricultural regions of REA's service territory tend to have high seasonal loads from grain dryers. This image shows grain bins in one of these regions. Photo by Runestone Electric Association.

How Zero-Carbon Ammonia Reduces Costs

Runestone Electric and Great River Energy work with University of Minnesota researchers on the use of portable, ammonia-fueled engines to defer costs.

By **AL HAMAN**, Runestone Electric Association, and **JEFF HAASE**, Great River Energy

For Runestone Electric Association, agricultural activities always have been an important consideration in electric grid operations and planning. Farmland accounts for a large portion of its service territory in west central Minnesota. In recent years, it has had to keep a particularly close eye on large loads from crop drying.

For about six weeks during harvest season, numerous farms across the region use large electric fans to dry corn and soybeans. The drying process also relies on electric augers to transport dried crops to silos for storage. In 2016, Runestone Electric Association (REA) had to build a new substation after experiencing persistent voltage problems because of the concentration of crop-drying in a 10-sq-mile (26-sq-km) area. Existing grid infrastructure could not accommodate the loads.

Investing in a new substation is not an ideal solution to serve a six-week load. Given that similar challenges could emerge in other areas, REA has been exploring alternative ways to defer or avoid such investments. One promising approach involves the use of portable engines powered by zero-carbon, or green, ammonia. While most ammonia worldwide is made with processes that use fossil fuels, green ammonia is produced with renewable energy.

Green Ammonia's Potential

REA and its wholesale power supplier Great River Energy (GRE) have learned about green ammonia's potential through the University of Minnesota's West Central Research & Outreach Center (WCROC), which conducts applied agricultural research for farmers and rural communities. In 2013, WCROC — located just an hour's drive from REA's headquarters — commissioned a first-of-its-kind facility that produces green ammonia with wind power. WCROC is currently building a larger-scale version of the facility.

REA and GRE are collaborating with several departments at the University of Minnesota, including WCROC, to determine whether portable, ammonia-powered engines, also known as gensets, can be connected to the distribution system as a

The University of Minnesota's West Central Research & Outreach Center commissioned a first-of-its-kind facility that produces green ammonia with wind power. Photo by University of Minnesota.

Farmers in REA's service territory typically use grain dryers to dry their corn during harvest season. Photo by University of Minnesota.

non-wires solution to serve short-duration, high-demand loads like crop drying.

How To Dispatch Optimally

A researcher in the University of Minnesota's department of chemical engineering and materials science, Qi Zhang is modeling how to schedule dispatch of ammonia gensets optimally so REA can defer grid infrastructure investments for several years. The idea is to enable REA to move around a limited number of gensets to serve a larger number of short-duration loads. This approach could help REA to reduce its upfront capital costs for the gensets.

Zhang's research team is investigating whether a genset could have effectively served REA's historical crop-drying loads and avoided the 2016 substation investment. To inform the analysis, REA has provided the researchers with historical load and grid data from the area that experienced the voltage problems.

REA and GRE also shared qualitative descriptions of other disruptive loads expected in the future. One involves clusters of vacation homes that surround numerous lakes in REA's service territory. On Friday afternoons in the summer, throngs of visitors arrive at the lakes, turn on air conditioners and cook dinner with electric ranges and ovens.

While these residential loads have not overloaded the grid yet, they could become problematic for a few busy weekends each summer as more vacationers charge electric vehicles upon arrival. Ammonia gensets are a particularly attractive solution because the cost of building new lines in these areas is high.

The researchers are evaluating whether grid-connected gensets could address the lake scenario in the summer and then be transported to other locations. For example, a genset could be used in lake country for the July 4th holiday and other high-demand summer weekends and then moved 60 miles (97 km) to the far western part of REA's grid to serve crop-drying loads in the fall. During other times of the year, the genset could be connected to the grid at strategic locations to reduce wholesale market purchases when prices are high. This could be particularly impactful during high-demand periods.

Zhang's team provided REA and GRE with sample genset dispatch schedules. REA and GRE have reviewed the schedules and suggested the team revisit the analysis to account for in-field operational factors, such as genset start-up times, the amount of time gensets are needed at specific locations and the logistics of supplying ammonia. This collaborative approach has helped to refine the analysis.

According to the research, with a few portable, strategically located gensets, REA could shave problematic local peaks and defer investments for several years. Furthermore, when it did move forward on a capital investment, a genset would be available for the next emerging problem.

Developing Ammonia Gensets

In parallel, REA and GRE are collaborating with the University of Minnesota's department of mechanical engineering's Will Northrop and Seamus Kane, who are developing gensets to be tested on REA's system. Prior research by Northrop and Kane has shown ammonia can be used as fuel for spark-ignition engines. However, to optimize the fuel for combustion, the engine needs to convert about 10% of the ammonia to hydrogen. Their next research step is to develop an engine that runs on 100% ammonia.

REA has provided the researchers with its preferences on the genset's operational features. These include portability, the ability

Runestone Electric and Great River Energy are collaborating with the University of Minnesota's West Central Research & Outreach Center, pictured here. Photo by University of Minnesota.

to run for multiple days at a time and the ability to easily transport ammonia to the genset site.

REA informed the researchers of the maximum genset power output its distribution grid could accommodate. Additionally, the genset would need to be safe and leak resistant, particularly for applications in residential areas.

REA and GRE have given Northrop and Kane a valuable perspective on the unique power delivery requirements in rural regions, where electric cooperatives typically use trailers to transport gensets over long distances. This information enabled the researchers to adapt their ammonia genset design for rural areas, thereby significantly broadening the potential number of applications for the technology.

Commercialization is close. Northrop and Kane plan to demonstrate their first 250-kW ammonia-fueled genset in 2024. WCROC's production facility will supply the green ammonia for field tests on REA's grid.

In the meantime, Northrop and Kane are developing safety measures to prevent ammonia leaks and minimize harmful emissions. While ammonia-powered gensets have no carbon dioxide or particulate emissions, they can emit nitrogen oxides (NOx), nitrous oxide and ammonia. The researchers' work to date has shown optimizing the ammonia combustion process can reduce NOx emissions to levels comparable to that of a diesel engine. They are working with a catalyst supplier to reduce combustion emissions of NOx, nitrous oxide and ammonia to near zero.

Northrop and Kane expect ammonia gensets to take 30 seconds to 120 seconds to ramp up to full power — like fossil-powered gensets. Ramp-up may be a bit longer when ambient temperatures drop below 0°F (-18°C).

The researchers expect ammonia and fossil gensets to have comparable maintenance costs as well, though ammonia gensets potentially offer some advantages on maintenance. Unlike diesel and gasoline, ammonia fuel does not degrade or produce ash and soot when burned in engines. As a result, oil in the genset is less likely to foul, or become dirty, and can last longer. That said, the researchers have not conducted long-term run

experiments on ammonia gensets and concede there is still more to learn about their durability.

According to Kane, a utility would need about 6200 gal (23,470 liters), or 16 tons, of ammonia to run a 250-kW ammonia genset for 100 hours continuously. A semitruck could transport to the genset site nearly double this amount with an 11,500-gal (43,532-liter) tank on a trailer. The truck can refill a genset's fuel tank while the genset is generating power.

Synergies With Agriculture

The Midwest's agricultural industry relies heavily on fertilizer made with conventional, fossil-based ammonia. As a result, the region already has extensive, mature infrastructure for safe, reliable ammonia handling, storage and transport. Ammonia safety is important because the material can be corrosive and toxic if inhaled.

For REA, GRE and other Midwest utilities exploring green ammonia applications, intriguing possibilities exist for collaboration with agricultural entities and fertilizer companies on ammonia production, storage, transport and use.

For one, the timing of ammonia use across the utility and agricultural sectors is potentially complementary. REA would need ammonia in the summer for lake country, fall for crop drying and winter for areas with high heating demand — times of the year when farms typically do not use fertilizer. Spring is the peak fertilizer season for farming. What is more, conventional ammonia potentially can be replaced with green ammonia without significantly disrupting agricultural operations.

A team of University of Minnesota researchers have envisioned a system that couples the agricultural and energy sectors by taking advantage of the synergies between them. The system would use renewable energy for several applications across the two sectors:

- Produce ammonia for fertilizer, tractor fuel and crop drying
- Serve local electricity demand
- Export excess power to the grid.

For such a system to work, its design and scheduling would need to be optimized carefully to account for the variability of renewable generation as well as variable power and ammonia demand across hourly and seasonal time scales. The researchers have demonstrated the promise of an optimization approach. The demonstration used a case study in which wind turbines serve demand for ammonia fertilizer and fuel at WCROC's farm as well as serve electric demand at the adjacent University of Minnesota campus in Morris.

For GRE, green ammonia production offers a potential opportunity to absorb excess wind generation on its transmission grid, balance energy supply and demand, and avoid back-feeding because of high wind penetration. The ammonia can be used to electrify tractors and other fossil-powered agricultural end uses. Meanwhile, agricultural ammonia storage facilities could serve as an electricity sink.

One of REA's members operates a large ammonia storage facility. If GRE or REA ever need to store energy by producing and storing green ammonia, they could leverage that member's capabilities rather than having to reinvent the wheel and deploy their own storage facilities.

By taking advantage of these synergies between industries, utilities like GRE and REA have a unique ability to help agricultural producers reduce their carbon emissions. In fact, WCROC research has shown displacing conventional ammonia with green ammonia in fertilizers and crop drying could lower agriculture's fossil energy consumption by nearly 80%.

Final Thoughts

It has been a worthwhile experience to combine multiple academic research avenues to address a real-world utility challenge. On one hand, REA and GRE have benefited by gaining valuable insights on a zero-carbon solution to a costly problem. On the other hand, the on-the-ground perspectives of REA and GRE have helped University of Minnesota researchers to refine their assumptions and make their investigations less theoretical and more practical.

Advances in ammonia genset applications by REA, GRE and the University of Minnesota can inform utilities across the U.S. — particularly in agricultural regions — in their grid operations and planning. Ammonia's potential for multifaceted uses could enable utilities to leverage existing fertilizer infrastructure to boost the use of clean energy while solving local grid challenges. TDW

AL HAMAN (*al.haman@runestoneelectric.com*) is CEO of Runestone Electric Association (REA), an electric distribution cooperative serving 15,000 accounts in rural Douglas, Pope and Grant counties in west central Minnesota. Prior to joining REA, he was CEO of STAR Energy Services from 1999 to 2020 and an electrical engineer at Otter Tail Power from 1991 to 1999. He is a graduate of North Dakota State University and a registered professional engineer in Minnesota, North Dakota, South Dakota and Wisconsin.

JEFF HAASE (*JHaase@grenergy.com*) is director of member services, distributed energy resources and end use strategy for Great River Energy (GRE). He works with GRE's member-owners on growth and distributed energy resource strategies related to energy efficiency, electrification, economic development and demand response. He focuses on optimizing GRE's program offerings and quantifying their benefits to member-owners. He has a BSME degree from the University of Minnesota and is a registered professional engineer.

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Wind Turbines Phase 1 & 2 Project around the Lam Takong Jolabha Vadhana Reservoir.

Thailand Harnesses Wind Energy Potential

Thailand's EGAT installs a wind-hydrogen hybrid system with fuel cell technology at the Lam Takong Jolabha Vadhana power plant.

By **PRAPAPONG VANGTOOK**, **PANU SUWICHARCHERDCHOO** and **JARUDATE VORASEE**,
Electricity Generating Authority of Thailand

Renewable energy sources have been gaining momentum in power generation over the last decade due to decreasing costs and breakthroughs in renewable energy technologies. Furthermore, many countries are now committed to achieving a clean, secure and reliable power supply. In 2015, the United Nations established 17 sustainable development goals, including affordable and clean energy, sustainable cities and communities, and climate action. During the 26th session of the Conference of Parties (COP 26), commitments were made at the United Nations Framework Convention on Climate Change in Glasgow 2021.

The facilitation of renewable energy resources integration is required to mitigate climate change in the energy sector. Global electricity consumption is expected to grow exponentially, which will lead to an increase in electrical energy generation. Renewable energy resources will play a significant role in fulfilling this demand and providing a sustainable energy transition.

Thailand is one such country that has seen considerable growth in electricity consumption because of continued economic growth, including population growth. As a result, the country updated its Power Development Plan 2015 (PDP2015) as PDP2018 Revision 1 to focus on electricity generation that could keep up with the increasing electricity consumption and would make the most of renewable power generation technology improvements.

Wind Energy Growth

Electricity generation from wind energy in Thailand began as a pilot project at Laem Phromthep on Phuket Island in 1983 by the Electricity Generating Authority of Thailand (EGAT). EGAT chose this location because the annual average wind speed throughout the year at hub height is around 5 m/sec (16.4 ft/sec). With a total capacity of 170 kW, the wind farm is still operational after almost 40 years in service and continues to generate electricity.

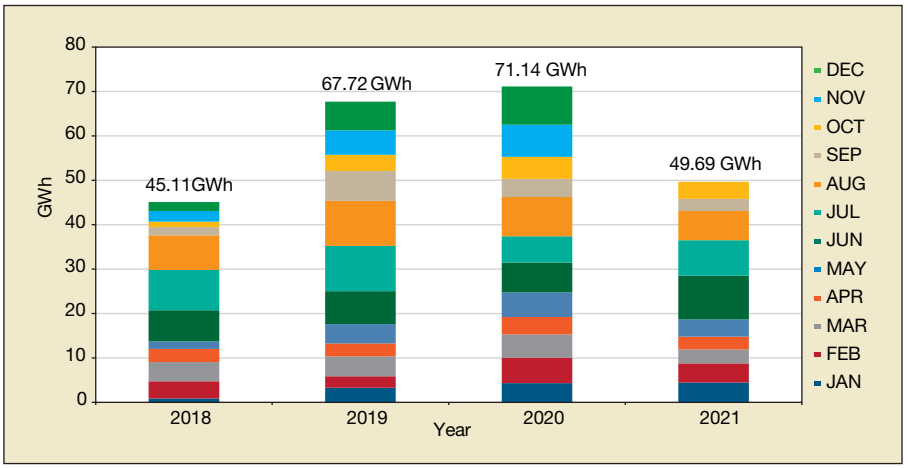
Following the success of this pilot project, EGAT has continued to explore potential locations to install new onshore wind turbines. The deployment of wind power generation in Thailand has grown at a moderate rate even though the country experiences relatively low wind speeds.

In 2008, the utility established two groups of 1.25-MW wind turbines with a total capacity of 2.5 MW, which was the largest wind farm in Thailand at the time. The wind farm also has an

annual average wind speed of about 5 m/sec to 6 m/sec (16.4 ft/sec to 19.7 ft/sec). It is located at the upper reservoir of the Lam Takong Jolabha Vadhana power plant in Khlongphai, a subdistrict of the Sikhio District, Nakhon Ratchasima.

From 2017 onward, wind turbine installations have increased exponentially, with a growth rate of about 70% per year. In 2019, Thailand installed new wind turbines with a cumulative capacity of 404 MW, increasing the total capacity of wind power generation to 1507 MW. The total capacity of 1507 MW is halfway toward the 3-GW goal EGAT set in its PDP2018 and Alternative Energy Development Plan (AEDP). More than one-half of new wind turbine installations have been in the northeastern region of Thailand, followed by the southern region, northern region and central region, respectively.

The security of energy has been a major issue for Thailand, as more than one-half of its energy production relies on natural gas. With the depletion of natural gas reserves and in consideration of its COP26 commitments, the Thailand government has stepped up to diversify the country's electricity generation from renewable energy resources, particularly solar energy and wind power generation capacity.

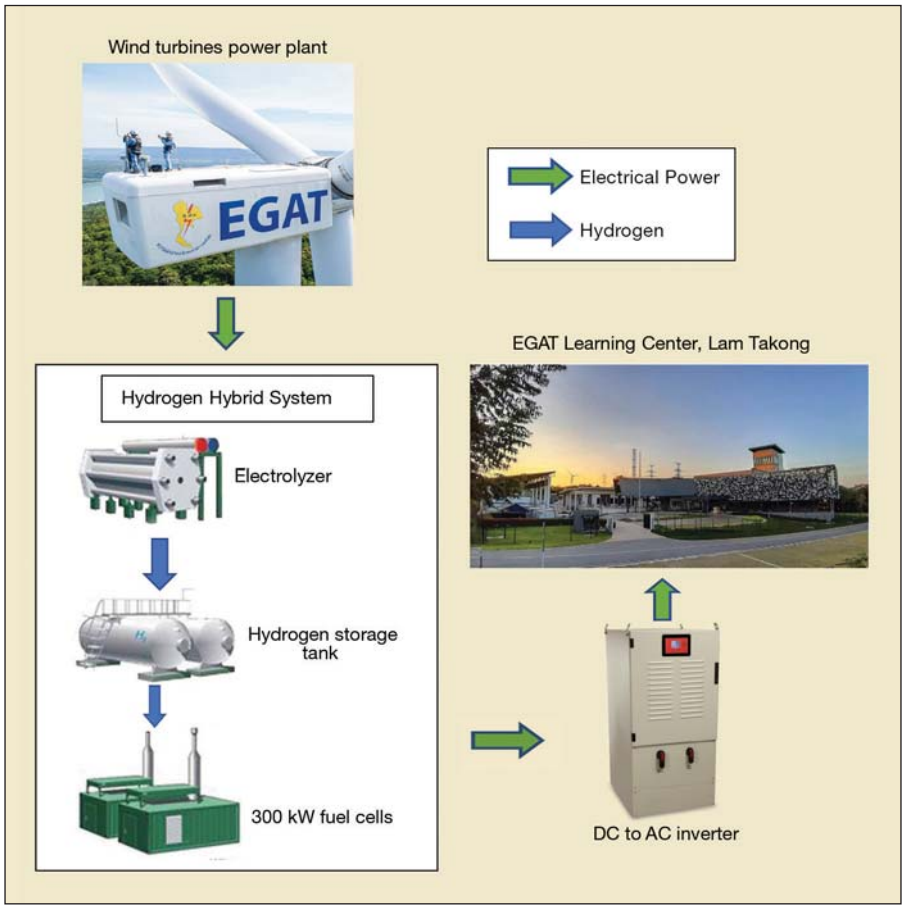


The yearly energy production in 2018 - 2021 (GWh).

Subsidies For More Growth

As a wind energy subsidy, a feed-in tariff (FiT) was launched in 2015 with a ฿6.06/kWh (US$0.176/kWh) energy tariff for 20 years. The subsidy was considered successful because the project attracted several developers, generating more than 1500 MW.

A new FiT subsidy is expected to be lower than the previous subsidy, and competitive bidding will reflect the drastic cost reductions in wind turbine technologies. This reduction will enable wind energy markets to determine the actual price wind energy projects should be paid and minimize the risk of excessive subsidizing. The goal is to attract the development of wind energy and forge strong partnerships with the wind energy industry. The



The layout of the hydrogen hybrid plant.

new subsidy will undoubtedly strengthen wind energy production and generation capacities across Thailand.

Regional Wind Potential

Thailand is located near the equator and has relatively low to moderate wind speeds. Its northeastern, western and southern regions have the most significant wind energy potential. An annual average wind speed is about 6 m/sec at 50 m (164 ft). However, those areas are very remote from load centers and transmission lines.

The technical potential of wind energy could reach 13 GW across Thailand. The offshore wind energy potential has been studied, and the Gulf of Thailand offers the most promising area, with an estimated magnitude of 7 GW. More than one-half of the potential is in the Bay of Bangkok, the northern part of the Gulf of Thailand. Assuming a capacity factor of 25% at a hub height of 120 m (394 ft), the total energy generation would reach 15 TWh per year.

Wind Challenges

Thailand faces many challenges in the development and promotion of wind energy. Three of the challenges are as follows:

1. Land and community issues remain problematic for wind farm projects. The average wind speed of Thailand is low to medium range. The potential wind energy areas are around the Thai Gulf and higher-elevation regions, with an average wind speed between 5 m/sec to 6 m/sec at around 50 m. Wind farms require significant space to operate, and most of the potential area with the highest average wind speed is often in mountainous terrain or reserved forests. Therefore, installing a wind turbine requires permission from the related government agency to use the area.

2. Wind farm projects require high capital investment costs to pay for the wind turbine grid connection, civil work and construction, in addition to the fixed and variable operating and maintenance costs. Therefore, a reasonable energy tariff would be necessary for wind farm projects to break even within their lifetime.

3. Environmental impacts are inevitable around the area of the wind turbine. For example, a wind turbine could negatively impact the scenery, cause noise pollution and harm animals, for example. A preliminary environmental impact analysis (EIA) is required to help manage stakeholder relations.

Power Plant Case Study

Following the successful wind turbine project of two sets of 1.25-MW wind turbines installed in 2008 at the Lam Takong Jolabha Vadhana power plant, the annual average wind speed was 5 m/sec to 6 m/sec over the upper reservoir of Lam Takong Jolabha Vadhana.

This was considered a good site for expansion of the wind farm. In June 2017, EGAT developed a second phase of the project, installing an additional 12 wind turbines with a total capacity of 24 MW, or 2 MW each, for a total power capacity of 26.5 MW. Each turbine is 94 m (295 ft) high with a rotor diameter of 116 m (381 ft). The project cost ฿1.4 billion (US$40.8 million), and the Phase 2 Takong wind turbine project was commissioned in April 2018. Energy production from this wind turbine farm supplies many households in the area. The recorded wind energy produced from 2018 to 2021 was 45.11 GWh (2018), 67.72 GWh (2019), 71.14 GWh (2020) and 49.69 GWh (as of October 2021) , with capacity factors of 21.92% (2018), 32.83% (2019) and 31.43% (2020), respectively.

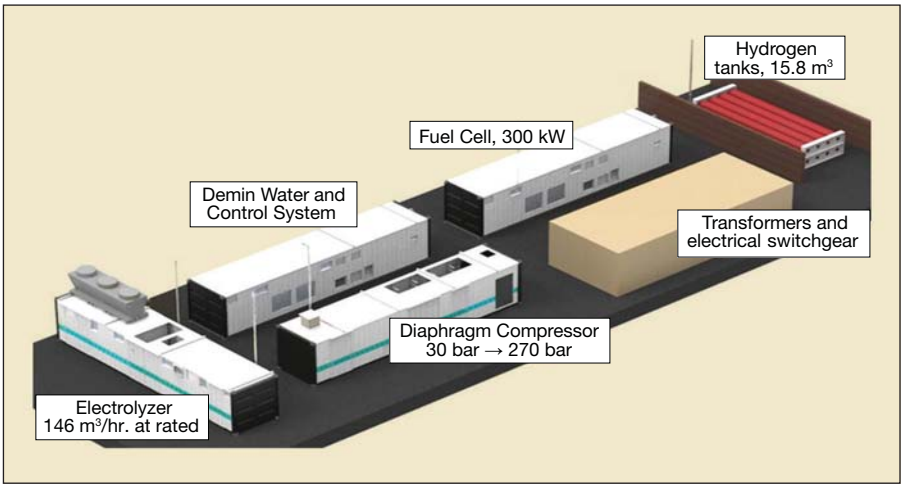
Table 1. Fuel cell specification.

Characteristics	Unit	Value
Fuel Cell	kW	300
Start-up time of fuel cell	Minutes	2.5
Start-up time for electrolyzer	Minutes	1.0
Rated hydrogen gas generation	M3/hr (35.315ft³/hr)	146
Round trip efficiency	%	30

In addition, the second phase of this project was enhanced with the installation of hydrogen fuel cell technology, with a magnitude

of 300 kW among other specifications. Energy production from wind turbines is used to separate water into hydrogen and oxygen. The hydrogen is then transferred to the fuel cell to generate electricity. The fuel cell was intended to supply the EGAT learning center in the area. The total cost of the fuel cell system was around ฿234 million (US$6.79 million)

The EGAT wind hydrogen hybrid system with fuel cell technology was not only the most significant project in Thailand but also a first for Asia. The project will help to stabilize energy generation from renewable energy and diversify the mixture of electricity generation in response to the Thailand's policy.



Hydrogen fuel cell system.

Untapped Potential

A large wind-energy potential in Thailand remains untapped. Wind energy will help the country to meet its total energy consumption. In 2019, new installations of wind turbines were 404 MW, bringing the cumulative capacity of wind power generation to 1507 MW. The growth rate of wind energy between 2017 and 2019 has been around 75% each year, and it is expected to increase. By the end of 2036, new wind energy integration will be about 1485 MW, which will lead to a national cumulative capacity of wind power generation up to 3 GW, or accounting for 30% of the country's total power generation from alternative energy, according to PDP2018.

Most of the wind turbines at the 24-MW wind farm installed at the Lam Takong Jolabha Vadhana power plant operate optimally with slight seasonal wind variations of both speed and direction. The capacity factor of this wind farm represents a high value of 31.97%, which shows the efficiency of the power plant.

Conversely, the availability is unstable and needs improvement, varying from 57.29% in January 2019 to 97.22% in August 2020. The reasons for this huge variation are attributable to a

Thailand as a country has a lot of untapped wind power potential. Photo by Ibigblue Dreamstime.

forced outage with issues on spare part replacement requirements (almost all spare parts purchased from original equipment manufacturers), a forced outage because of a line-to-ground fault and a planned outage for yearly inspections (semiannual and annual inspections).

Future work will monitor other wind farms' performance in Thailand. The EGAT wind hydrogen hybrid system with fuel cell technology has increased the availability and reliability of electricity. Hydrogen is generated during off-peak hours at night and used during peak hours in the daytime. The renewable energy generated from wind turbines at the Lam Takong Jolabha Vadhana power plant can supply about 0.8% of Nakhon Ratchasima province's electricity demand. This is helping Thailand to comply with the commitments made during the COP 26.

Thailand's Greenhouse Gas Management Organization set the coefficient of greenhouse gas (GHG) emission factors from electricity generation as 0.5692 total carbon dioxide/MWh. From January 2018 to October 2021, the carbon dioxide was reduced by 132,996.08 total carbon dioxide. During the 46 months of operation, the wind turbine produced electricity sufficient to cover 48% of the installation cost as a fixed cost. Therefore, EGAT will reach the break-even point after the next five years, which does not include operation and maintenance costs. TDW

DR. PRAPAPONG VANGTOOK (*prapapong.v@egat.co.th*) graduated with a doctor of engineering degree in energy technology from the Asian Institute of Technology. He is a senior mechanic engineer in the research and innovation division at EGAT.

PANU SUWICHARCHERDCHOO (*panu.s@egat.co.th*) graduated with a MSME degree from King Mongkut's Institute of Technology North Bangkok. He works at EGAT's Lamtakong Jolabha Vadhana hydropower plant.

JARUDATE VORASEE (*jarudate.yor@egat.co.th*) graduated with a master's degree in renewable energy and clean technology from the University of Manchester. He is an electrical engineer in the grid modernization technology department at EGAT.

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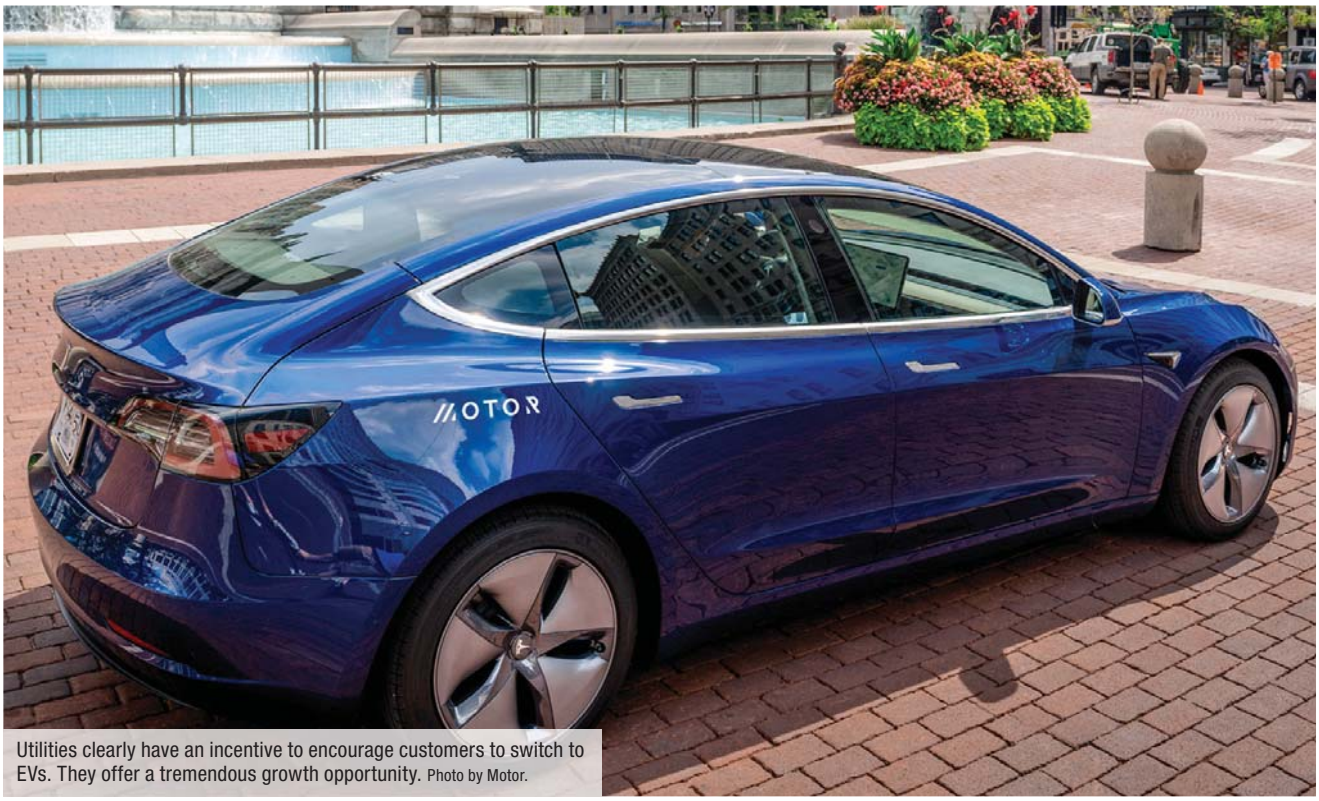

Utilities clearly have an incentive to encourage customers to switch to EVs. They offer a tremendous growth opportunity. Photo by Motor.

AES Indiana Powers The Future of Transportation

The utility partnered with Motor to accelerate electric vehicle adoption in its service territory by offering a unique program to residential customers.

By **PRAVEEN KATHPAL**, Motor, and **BRANDI DAVIS-HANDY**, The AES Corporation

By facilitating and accelerating the adoption of electric vehicles, utilities can manage their inevitable load growth better, increase revenue, connect customers with cleaner, more cost-effective transportation solutions, and support local, state and national climate goals. Simply put, utilities are best positioned to ensure uniform adoption is available equitably across varied geographies and socioeconomic levels.

The transition from fossil fuels is forging ahead, and it is not just environmental leaders propelling the movement. The federal government aims to achieve a carbon-free energy sector by 2035 and a net-zero emissions economy by 2050. To meet these and other climate goals, government and industry must work together to address the major contributors of emissions swiftly.

The transportation sector is the largest contributor of U.S. greenhouse gas emissions, according to the U.S. Environmental Protection Agency — the overwhelming majority of which comes from light-duty vehicles, like passenger cars. In 2021, President Biden set a goal to make 50% of all new vehicles sold emit zero emissions by 2030. Numerous legacy automakers are even on board, and rightfully so. It has simply never been more important for Americans to make the switch to electric vehicles (EVs).

All the while, the electric utility industry is on the precipice of change. Utilities will play a critical role in driving the shift to EVs, and there is strong public interest for them to do just that. According to a June 2022 Edison Electric Institute report, the number of EVs on the road is projected to reach 26.4 million, or 10% of all light-duty vehicles, in 2030. While that represents a rapid, significant increase from the current figure of around 5%, it simply is not enough to meet U.S. goals.

Accelerating Adoption

Seeing the vast potential for electricity-based transportation to curb carbon emissions, a team within The AES Corporation incubated Motor, a company that works with utilities to accelerate

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Seeing the vast potential for electricity-based transportation to curb carbon emissions, a team within The AES Corporation incubated Motor, a company that works with utilities to accelerate EV adoption. Photo by Motor.

EV adoption through its unique program for residential customers. Once implemented, customers can sign up through a fully digital process to have an EV delivered to their house — initially on a month-to-month subscription — with EV onboarding, home-charging installation and enrollment in the utility's managed charging programs.

After the initial subscription period, the customer has the option to buy an EV through Motor's fully digital experience that taps into local dealer inventory. The goal is to streamline what is currently a fragmented and difficult experience keeping customers from switching to electric. Customers get an easy, low-commitment, all-in-one way to begin their EV journey. And for utilities, Motor's turnkey EV adoption-as-a-service platform finally gives them more influence over adoption rates in their territory and a way to ensure customers enroll in their programs.

AES Indiana

AES Indiana has partnered with Motor since 2020 to get consumers into EVs faster and expedite the clean-energy transition. The partnership is a blueprint for the positive impact utilities can have on EV adoption while ensuring that the grid remains resilient and energy prices are affordable into the future. During the first year of its partnership with AES Indiana, Motor accounted for 20% of new EV adoption in Indianapolis, with an average load growth increase of 35% per member. Additionally, more than 75% of qualifying customers are enrolled in AES Indiana's new managed charging program.

Utilities clearly have an incentive to encourage customers to switch to EVs. They offer a tremendous growth opportunity to both expand utilities' customer base and increase the energy usage of existing customers in a planned, managed way. Managed charging programs enable better load forecasting to mitigate the potential for overloaded grids, which in turn

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Motor's turnkey EV adoption-as-a-service platform finally gives them more control over adoption rates in their territory and a way to ensure customers enroll in their programs. Photo by Motor.

benefits all utility customers. Accelerating EV adoption also spreads utilities' fixed costs over a broader customer base, enabling utilities to keep rates affordable while investing in cleaner energy.

For AES Indiana, the managed charging program Motor enrolls customers into has been extremely successful in encouraging off-peak charging. The majority of customers' EV charging occurs during off-peak hours, helping to delay additional infrastructure spending to serve capacity during peak hours.

An EV Partnership

Having a partner with an integrated adoption platform to guide customers through the EV journey has been a huge asset for AES Indiana and makes it easy to bring managed charging enrollment to the point in the customer journey when it is most relevant to customers — when they first get an EV.

The federal government also is encouraging utilities to convert to more sustainable energy sources — and even incentivizing it. The passage of the Inflation Reduction Act brings US$370 billion in subsidies for EVs and other clean-energy developments through extended and expanded tax breaks and other means.

Moreover, geopolitical instability and pipeline infrastructure challenges are driving painful fuel price increases for consumers. Switching from a gas-powered vehicle to an EV saves money on fuel costs and long-term vehicle maintenance costs while also reducing environmental impact.

Consumers are aware of this and are increasingly curious about EVs. A national Consumer Reports survey in 2022 found 71% of respondents had some level of interest in buying or leasing an EV. Yet only 9% said they were very familiar with the fundamentals of owning an EV. Those who are interested in EVs frequently find the process of acquiring a vehicle, obtaining insurance and figuring out maintenance overwhelming. Utilities are well positioned to demystify and simplify this process. Since Motor's turnkey EV services became available to AES Indiana customers, those who enrolled have reported high levels of satisfaction with their EV experience.

The availability of public charging stations also is spotty and inequitably distributed at best, something EV dealers regularly cite as an obstacle to sales. Access to at-home charging with installation through Motor is a major selling point for AES Indiana's customers.

Utility customers are not the only ones who benefit from EVs. In Indianapolis, residents rely heavily on their personal vehicles to get around, fueling greenhouse gas emissions. Every resident in the city benefits from improved air quality by reducing auto tailpipe emissions.

States also benefit from utilities boosting EV adoption. Electrification plans and policies are in place in numerous states already. Almost every state in the U.S. now incentivizes zero-emission vehicle sales or adoption. More than a dozen states require auto manufacturers to sell a certain number of zero-emission vehicles annually. California has set 2035 as its target date for ending the sale of new gas-powered light-duty vehicles altogether, and several more states are likely to follow. Utilities are advancing these efforts by offering their own EV incentives, such as rebates, grants and off-peak charging price reductions.

Electric Ambitions

The future of energy is electric, and it is already upon us. Utilities must be ready to meet the moment and collaborate with governments, technology leaders and other stakeholders working toward climate and energy goals. The more EVs on the road, the faster these ambitions can be achieved.

Millions of Americans want EVs, but too few end up getting them. It must be as easy and convenient to acquire and use EVs as traditional fuel vehicles. Utilities like AES Indiana are essential to closing the gap between consumer appetite and adoption. And in doing so, they support their own business growth, enable a sustainable grid and help to make cities, states and the nation a healthier place to live. TDW

PRAVEEN KATHPAL (*praveen@trymotor.com*) is CEO of Motor, a fast-growing company that helps electric utility companies accelerate consumer EV adoption. He previously served as VP of New Business at AES Next and as VP of Market Applications at Fluence, a leading energy storage technology and services company. He has served as chair of the Energy Storage Association board of directors. Prior to joining AES, Praveen was a consultant at ICF International. He holds a BA in Economics and an MBA from the University of Virginia. Praveen is actively engaged in his community, serving on the City of Alexandria's Climate Task Force, and previously as chair of its Environmental Policy Commission.

BRANDI DAVIS-HANDY serves as chief customer officer for AES' utilities in Indiana and Ohio. Within this role, she leads a team focused on providing an exceptional customer experience and accelerating efforts on new solutions to help customers achieve their most important objectives of reliability, affordability and sustainability. Prior to AES, she served as Chief Marketing and Communications Officer at Project Lead The Way and has also led communications teams at OneAmerica Financial Partners and the American Cancer Society.

ELECTRIC UTILITY OPERATIONS

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Augmented Reality for Training Future Lineworkers

OUR MAY FEATURED LINEWORKER

Randi Blaser

Ameren Illinois

- Born in Kansas City, Missouri, and has four siblings, Donnie, Crystal, Brittni and Dylan.
- Mom of 14-month-old twins, Reigny and Beckett.
- Enjoys relaxing at home, spending time with her kids and fixing up her house.
- Can't live without proper climbing tools because she says as a lineworker, you don't know how many poles you will climb or how long you'll be on a pole.
- Bucket trucks, line trucks and power tools are essential along with new technology. Her crews are now learning how to access job packets on their iPads.
- In her area, there is a lot of work with underground services due to new home construction.

Early Years

Both my parents are in the trade. My dad, Ben, did line work for Kansas City Power & Light (KCP&L, now Evergy) and moved on to R&S Electric, and my mom, Susan, worked at KCP&L and now teaches the line tech program at Metropolitan Community College. I got interested in the trade back in my senior year of college at Missouri Western State University in St. Joseph, Missouri. I had been around line work my whole life, so it wasn't new or exciting to me, and I wasn't interested in it at first. One summer, however, my mom invited me and a close friend to come down to the school and just try the climbing portion of the class. After that, it was something I could see myself doing for a career.

Day in the Life

My first job working in the utility industry was as a groundman truck driver. In this stepping stone to my apprenticeship, I assisted the crews with ground work and learned about the basics. My current title is journeyman lineman for Ameren Illinois in Belleville, Illinois, and my responsibilities vary by the day. For example, I help to supervise apprentices, work with hot lines, do secondary work or perform troubleshooting. On a typical day, I show up in the crew room, review the safety message, stretch, discuss the jobs for the day and then load material and equipment. After we finish for the day, we head back to the plant to unload. My main responsibilities are to safely work on overhead and underground utilities and train the next generation of linemen. Right now, I'm working maintenance, new construction and on storms as needed. I plan to continue with these projects to get more experience.

Challenges and Rewards

Some major challenges for me have changed over the years, but one thing that will never change is my height. At 5 ft tall, I have to figure out different ways of doing things. At the same time, being short has its advantages too. Another major challenge is clothing. To be honest, women's FR apparel is still relatively new, and to find clothing that works within Ameren's policies is a challenge. I am in these clothes 40-plus hours a week, and I want it to fit me well. Some of the rewards of the job are overcoming challenges that arise on the job, seeing the work you did when you're done. In storm situations, sometimes the people are so grateful you are there to help them.

Line work runs in the family for Randi Blaser, who has both a mom and a dad who worked in the trade.

Safety Lesson

When I topped out, I learned about the importance of job-site safety. As an apprentice, you have basically no responsibility, but when you top out, all of that changes. Now apprentices are looking at you for answers, and you must watch everything you and others are doing to be safe. Everybody sees things differently, so if you see something, you need to say something.

Memorable Storm

My most memorable storm would be the time we went to the Ozarks in Missouri. I was still an apprentice, but I was far enough along I could contribute and knew what was going on. There were poles and wire down everywhere, and I could see truck after truck after truck. It was a surreal experience. We were only on the project for two or three days. The working conditions weren't bad compared to other storms. We worked in warmer weather and in the daylight. A tornado had gone through a small town, and we were assigned to fix anything broken on a circuit. This storm sticks out to me because I went with a good crew, and I could do most of the work, and it was fun. This experience is what made me really like line work.

Future Plans

If I had to do it over again, I would go the same route as I did. I feel like my learning experiences definitely shaped me into who I am as a lineman. My future plans right now are to just get more experience under my belt and continue to learn every day. 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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Tuning into Technology

MidAmerican Energy partners with Des Moines Area Community College to launch augmented reality training.

By **AMY FISCHBACH**, Field Editor

To power America, the energy industry will need to hire about 500,000 new employees over the next decade, according to the Center for Energy Workforce Development. As more lineworkers move into retirement, utilities nationwide are searching for more skilled workers in the line trade. Currently, however, few colleges offer programs for the line mechanic trade, according to Chelsea McCracken, MidAmerican's vice president of safety, training and development.

"Two-year wait times are commonplace, and it can be difficult to get students through fast enough to meet the needs of the workforce," she said.

To address the continuing workforce constraints in the utility industry, Iowa companies joined forces to develop a curriculum for the electric utility technology/powerline program at Des Moines Area Community College (DMACC). The advisory committee tackling the labor shortage issue included representatives from two investor utilities, Iowa rural electric cooperatives, municipal utilities in Iowa, International Brotherhood of Electrical Workers (IBEW) and DMACC.

For MidAmerican, bringing the digital training curriculum to DMACC not only gives college students the opportunity to earn an associate's degree in electric utility technology, but also extends the strategic investments the company has made in worker education.

Training the Next Wave of Lineworkers

MidAmerican first began exploring digital training back in 2017. A few years before, the company entered into an agreement with its labor unions to optimize resources by combining its two primary time-based gas apprenticeship programs into one competency-based hybrid program.

"The need for innovative, engaging training was evident, as apprentices were required to retain more information over a shorter period of time," McCracken said. "MidAmerican turned to Index AR Solutions to help pair augmented reality-based visualizations with written content and other multimedia for a complete digital training curriculum that was put in the palm of every apprentice's hand via a tablet in 2018."

To date, MidAmerican has digital training curriculums for 13 apprentice programs either complete or in development. The interactive training technologies deployed by MidAmerican have proven valuable in supporting a younger, higher-turnover workforce. Employees in the first 10 years of their career have, on average, a median tenure of about three years on the job, compared to retiring workers who have on average about 10 years on the job.

So MidAmerican Energy partnered with DMACC. By building a strong relationship with the community college, the utility could jump-start a training program with help from technology partner Index.

DMACC instructor Don Finn uses Index eBooks and apps to teach transformer wiring configurations to community college students. Fifteen students were enrolled in DMACC's first Electric Utility course with digital training materials, and the class size will double in the fall of 2023.

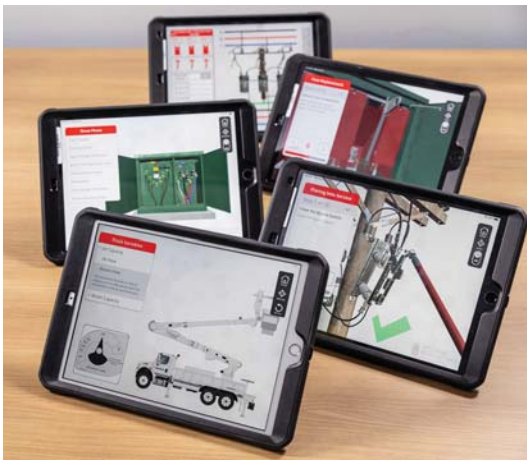
The students enrolled in the line mechanic program at DMACC now have access to the same material and content deployed in MidAmerican's own training centers. This approach ensures a consistent and predictable competency level of skill developed with each student.

"It is already field-proven and gives students a preview of the specific technologies, processes and procedures that they will experience if hired at MidAmerican," says Don Finn, instructor at DMACC. "The content, delivered via assigned tablets, then becomes a reference material that workers take with them outside of the classroom. Ultimately, using the same training material builds excitement and gives students

a great concept of what the job is really like."

Learning the Technology

So far, the students have responded positively to the curriculum created by Index, Finn says. As with any technology, the virtual training curriculum has a learning curve for some users, even for younger students who have grown up around mobile devices. To help these students, the vendor works closely with DMACC to overcome any challenges with learning the technology.



Each DMACC student enrolled in the new Electric Utility course receives a tablet loaded with 17 interactive eBooks and 12 augmented reality applications developed by Index in partnership with MidAmerican.

In addition to delivering the training materials and iPads to DMACC administrators, Index provided ongoing support so instructors and students can gain maximum benefit from the course. Index team members hosted "train-the-trainer" sessions on-site for DMACC instructors, and they arranged weekly videoconference calls for students over the course of the semester to walk them through each eBook and app step by step. Because most of the students identify themselves as hands-on learners, they have been able to navigate the training program materials on the iPads.

In the Transformer Trainer application, students tap and drag across the screen to make wiring connections and then receive instant feedback on whether a connection was made correctly. Rather than having to flip through pages of text, students also enjoy the searchability of the tablet-based materials. Students can simply type in a search and quickly locate important topics. They can also bookmark a topic and type notes instream for reference later.

Transferring Knowledge

During the classroom portion of the training, Finn uses the tablet as a tool in class, walking through multimedia content and visualizations projected on a screen while students follow along on their own tablets at their desks. The instructor has also used the material to develop exams that the students complete during the year-long program.

"The digital curriculum is a fundamental shift in the way linemen are trained," Finn says. "Instead of static, one-dimensional textbooks, apprentices now consume instructional material in the form of rich multimedia that is also interactive."

The line mechanic course created by MidAmerican and Index includes nearly 1,000 eBook pages of vetted content and 200 instructional videos of actual line mechanics performing work and giving guidance. The videos also emphasize the importance of safety and commitment to customer service with seasoned workers who share wisdom and real-world stories from the field.

"MidAmerican's represented workforce was highly engaged in the development of the digital curriculums, and hundreds of apprentices, journeymen and others participated in the content gathering process," McCracken said. "Having safety-specific information delivered to apprentices and students by their fellow employees is a powerful tool to emphasize its importance."

To aid in knowledge retention, Index integrated brief YouTube-style videos into the training materials. The format also makes it easy to inject safety warnings and human performance tools into the visualization applications and eBooks to keep safety top of mind.

The tablets feature interactive Index mobile apps that use augmented reality (AR), three-dimensional models and animations to teach students how to identify key parts or complete common tasks, such as how to troubleshoot a transformer. The augmentations also walk students through the safety considerations and tools needed for each step and overlay critical information on to the component they are studying.

The interactive visualization apps such as Transformer Trainer make it easy for students to understand if they are performing a task correctly or incorrectly. Students feel rewarded when mastering a certain task for the first time and are more confident as they move on to the next concept.

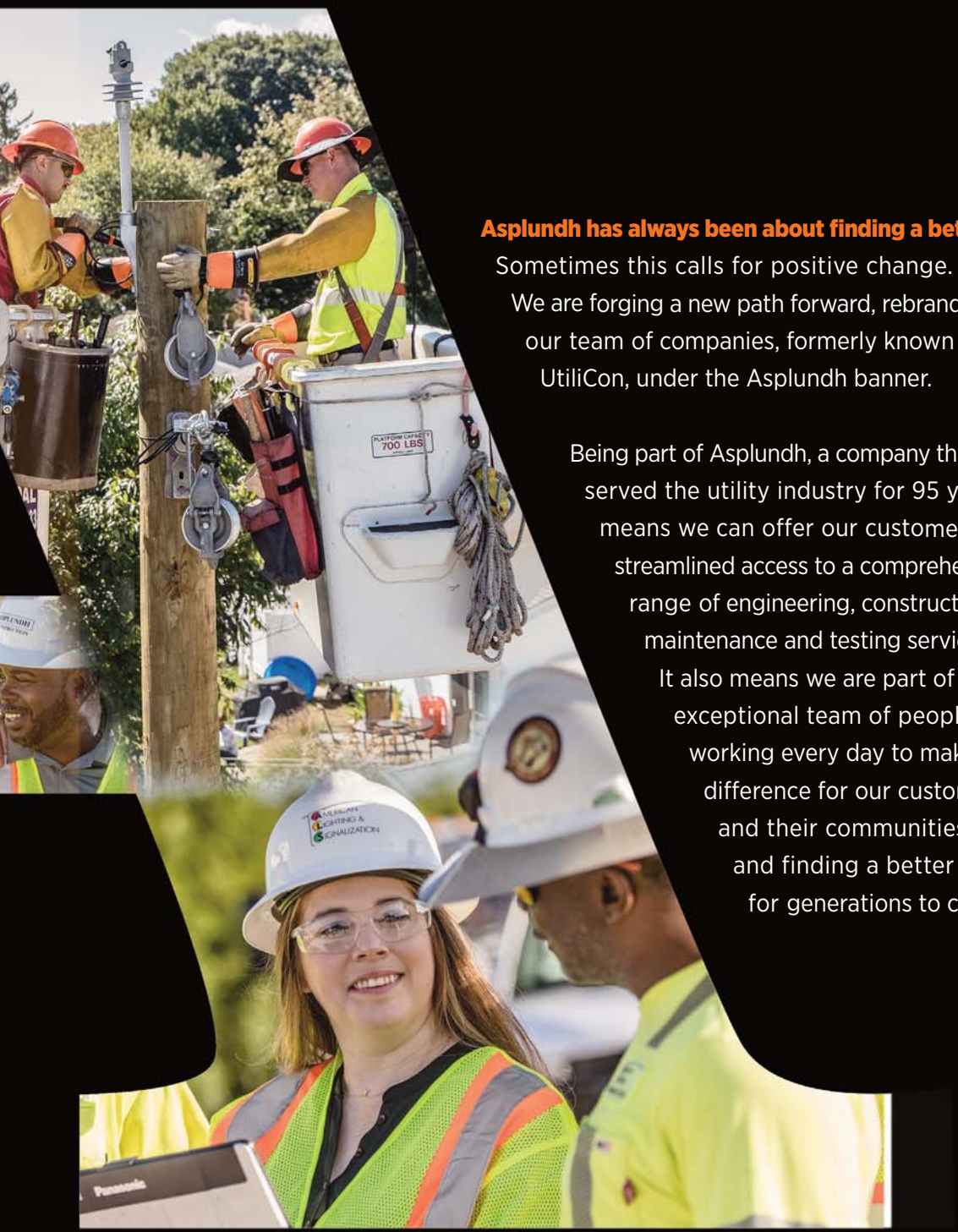
"Because the material is consumed on a mobile device, students can then take their learning tool directly into the training yard and refer to it as they complete the task on real equipment," Finn said.

Expanding the Program

With the training material delivered via tablets, the apprentices can access the information anywhere and anytime. Looking forward, MidAmerican is looking for a way to connect apprentices in the field back to trainers or subject matter experts when they need additional support.

To accomplish this goal, MidAmerican is exploring video-calling technology, such as FaceTime, so the apprentice can contact any trainer or subject matter expert remotely, show them the challenge they are facing and work through to a solution in real time. The company is also taking a close look at wearable technology, creating a hands-free tool for when apprentices are working on equipment both in training and in the field. TDW

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



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A combination of approaches allows data related to each transformer to be classified into one of several predefined classifications or states: normal, monitor, service, stable, replace and risk identified. Photo courtesy of Doble, image by AdobeStock.

Duke Energy's Hybrid Approach to AI

This hybrid model of engineered analytics and machine learning has proven to be an excellent but imperfect tool — more accurate than either pure AI/ML tools or engineered analytics alone.

By **TOM RHODES**, Duke Energy, and **TONY MCGRAIL**, Doble Engineering Co.

Artificial intelligence systems provide promise in analyzing and evaluating power system data. There is currently a large push to use artificial intelligence (AI) and machine learning (ML) to help reduce the time it takes to perform maintenance on transformers and predict where and when the next transformer will fail.

Major companies in various industries are promoting and telling the wonders of AI and ML: managing the replacement plans of an aging or aged fleet, reduction in maintenance while extending asset life, operational efficiency — all while capturing the available expertise so it is not lost. These are lofty goals, and claims are being made already about the benefits of AI applications in the real world. The problem is that AI is not perfect — but it still has a role in the analysis of well-described problems with sufficient data to cover all possible situations that may be identified.

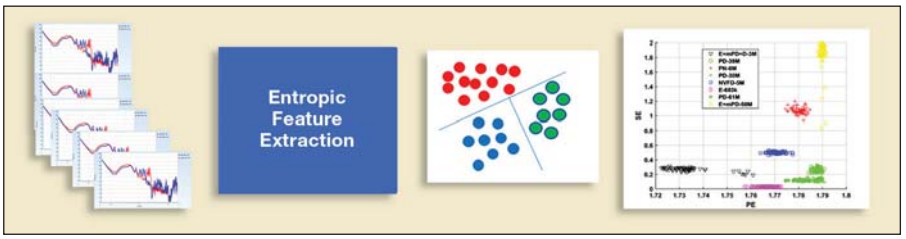
Now, consider two things that are true in the electric utility industry:

- Utilities are almost always faced with incomplete and possibly ambiguous data.
- Data analysis does not take place in a vacuum; utilities have a history and knowledge base to call on to check results.

In simple terms, if an AI system that analyzes data for power transformers is developed, then — based on the data available — it should be able to replicate what already has been developed as common knowledge or industry expertise. For example, in dissolved gas analysis (DGA), increased levels of

acetylene with increased probability of failure should be set as a rule.

If the AI is unable to state the rule in clear terms, then utilities might not trust other analyses described. They must have a believable audit trail for the analysis to justify actions.



Feature-extraction approach to EMI spectra analysis. Figure by Duke Energy.

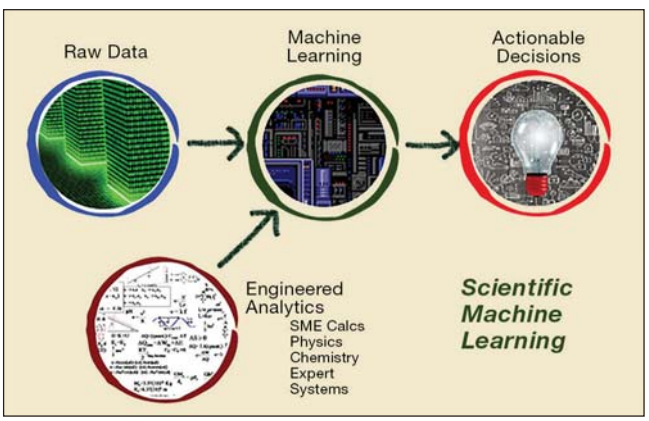
Business Environment

In an ideal world, utilities would have complete and detailed information on every transformer: maintenance history, test data, monitoring data, fault data and so forth. Standards and analytic tools would tell us about each individual transformer: health, probability of failure and remaining life, for example.

In practice, data may be incomplete, inconsistent or missing. It is common for subject matter experts and technicians to analyze and evaluate all available data to make decisions about actions and interventions in their region. Transformers often are ranked manually and grouped by prioritization of maintenance, replacement or other intervention. Individual analysis methods may be used by some experts but not others, and they may have their own specific approaches, meaning the analysis could be inconsistent based on the region and individual involved.

Therefore, the push to more uniform approaches based on AI and ML seems both rational and sensible, especially as many experienced personnel, who understand the data, are retiring.

So, what can AI and ML do for electric utilities? Following are some examples of benefits:



High-level overview of hybrid engineering ML transformer fleet analysis tool (SciML). Figure by Duke Energy.

- In weather forecasting, AI is used to reduce human error.
- Banks use AI in identity verification processes.
- Numerous institutions use AI to support help-line requests, sometimes in the form of chatbots.

Utility substation technicians performing routine maintenance. Photo by Doble.

- Siri, Cortana and Google Assistant are based on AI.
- AI systems can classify well-organized data, such as X-rays.
- On the downside, there are some issues with AI and ML:
- AI can be good at interpolation within a data set, but it might not be good at extrapolation to new data.
- "Giraffing" — the generic name for identifying the presence of objects where those objects do not exist — could provide bias in analysis based on unrepresentative data sets.
- Using a black-box approach could make the reason f or a decision not clear and transparent.

In fact, many of the benefits of AI applications rely on having clean and well-ordered data. In terms of data mining, it is estimated 95% of the possible benefits can be achieved through data cleanup and standard statistical methods.

It also should be noted AI systems can work 24/7 and do not get bored with repetitive tasks. So, an appropriate approach would be to apply today's AI tools where they are strong: analyzing data to identify the majority of standard or normal cases and enabling experts to concentrate on data that is not clear or needs real attention. Let the AI/ML interpolate but not extrapolate.

ML Types

In general, ML can be divided into two similar approaches, both requiring large data sets that are split into test and training subsets:

- In supervised ML, an expert classifies the data set into different cases, for example, oil samples that indicate overheating or paper degradation. An ML tool tries to learn from parameters within the data — for example, hydrogen content, moisture level and presence of partial discharge (PD) — to determine which parameters best reflect the expert classification. The resulting tool can be tested against new cases to see how effective it is.
- In unsupervised ML, a similar approach is used, but in this case, the ML tool groups the cases based on clusters in the many dimensions of the data provided. An expert then classifies the resulting clusters and tests against new cases.

As an example, consider an ML tool developed to recognize sheep and goats in pictures. In a supervised ML approach, an expert would classify each picture, and the tool would try to find data differences between the pictures that reflect the classification. It might not be clear why the tool does what it does, so the ML could be considered a black box. Once trained, an expert would show the ML tool more pictures for it to classify to see how well it does. If only pictures used in the training data are shown, it would likely do very well. However, if more complex pictures or pictures of another animal are shown, the ML tool might fail.

Technician conducts preventive maintenance on Doble condition monitoring solutions, which are designed to detect deterioration in bushings, find anomalies in insulation and monitor partial discharges in equipment such as transformers, rotating machines, cables and switchgear. Photo by Shermco.

In unsupervised ML, the tool clusters the data and the expert classifies it afterward. In both supervised and unsupervised ML tools, the ML tool performs very well when the test cases are like the training cases but not so well when the supplied cases are different than the training cases. What

happens if there are multiple animals in a picture? Or, if there is a llama — how would that get classified? The effect called "giraffing"— where an ML tool trained to identify giraffes in supplied pictures then identifies giraffes in pictures where no giraffe is present — is a result of ML training where giraffes are overrepresented in the training cases but the cases of no giraffes are underrepresented.

The effect can be seen in a visual chatbot that identifies the content of pictures but cannot tell how many giraffes are in a supplied picture, for example.

EMI Spectra ML Classification

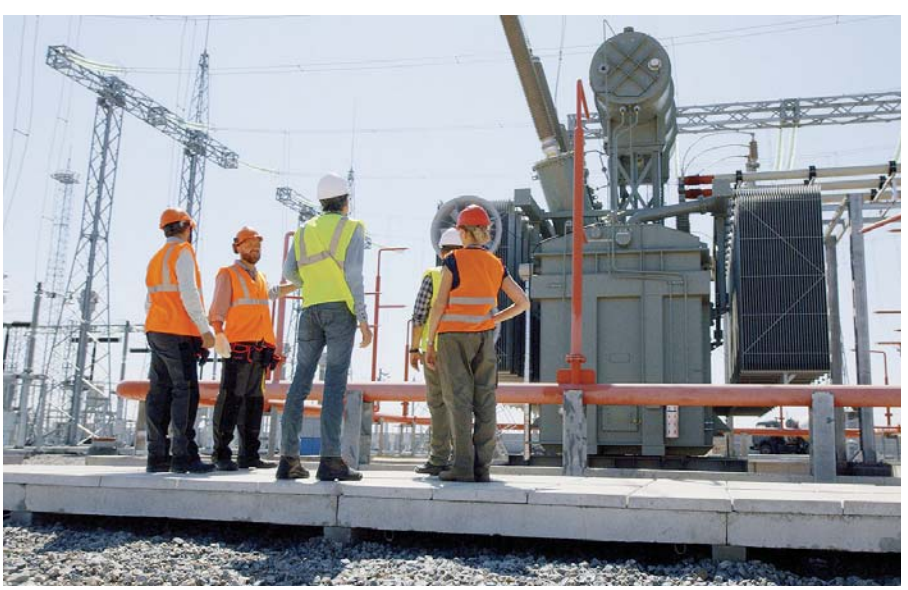
Dr. Imene Mitiche conducted a ML classification process for electromagnetic (EMI) spectra as part of a Doble-sponsored research and development project at Glasgow Caledonian University in the UK. Expert analysis of EMI spectra initially was used as the base for a supervised ML approach, where features extracted from the data — based on the entropy (orderliness) of the data — were used to cluster the data.

The original EMI spectra cases from numerous generator analyses taken around the world were analyzed and classified by an expert. Then those classifications were used to drive the supervised ML analysis based on the entropic features extracted. The supervised approach yielded an accuracy of approximately 75% upon subsequent testing. An unsupervised approach also was performed, using the same entropic data, with the clusters plotted on an entropy chart to indicate the cluster independence. Subsequent classification of the unsupervised clusters yielded an accuracy of over 80%.

The improvement in results from the unsupervised approach demonstrates both the difficulty in classifying the spectra and the benefits of not assuming prior knowledge from the expert. The resulting ML system is being incorporated into Doble's EMI survey tools to support users in the field with their analyses.

Standards and guidelines are available to support many analyses, noting these can be inconsistent and may not provide good interpretation in all cases. In practice, there is a need for entropic feature-extraction focus, as there is a lot of data.

Experts are regularly asked by the asset and finance group to provide a list of transformers most likely to fail or in the poorest condition for a proactive replacement project. Photo courtesy of Doble, image by AdobeStock.



A lot of time, effort and resources can be spent on ML systems that do not support the real world. Photo courtesy of Doble, image by AdobeStock.

For example, Duke Energy has more than 10,000 large power transformers (banks > 7.5 MVA) in its transformer fleet. These transformers have dozens of data sources — from DGA and off-line tests to maintenance history and condition monitoring — and they generate millions of individual data points. Like most utilities, Duke Energy has ever-fewer people to manage the aging fleet, so it must be able to focus on what is most critical, most important and most relevant.

There is currently a push to use artificial intelligence and machine learning to help reduce the time it takes to perform maintenance on transformers and predict where and when the next transformer will fail. Photo courtesy of Doble, image by AdobeStock.

Practicalities At Duke Energy

Duke Energy performed exhaustive research over numerous years looking for a good AI/ML tool. By good, the utility meant one that classifies cases well when they are clear and identifies those that are less clear as needing further analysis. One thing in common with every ML solution Duke Energy was offered or tried for predictive maintenance was an assumption that, given enough data, it could make accurate predictions using Gaussian modeling of the available data.

Unfortunately, that assumption is not true. A Gaussian, or normal, distribution is symmetrical about an expected value. In practice, distributions of DGA values, power factor levels, PD inception voltages, and others are not Gaussian — and that trend follows through the analysis to the point of classification.

The realities of transformer data are as follows:

- It can be limited and bad.
- Failed-asset data has not been documented and maintained.
- There has been no investment in cleaning and verifying available data.
- Data has not been normalized across multiple sources nor within a single source.
- There are unique characteristics of data related to the manufacturing process for sister units (that is, they are handmade).

In addition, data scientists must contend with these realities:

- Answers are assumed to be in the available data, without necessarily referencing transformer experts.
- ML assumes a Gaussian data distribution, but most failure modes are not based on Gaussian data.
- Major companies like Dow Chemical, Audi and Intel have been open about predictive models for major plant assets not being effective.
- IT and data scientists do not usually understand failure modes and may not take them into account for their modeling.

Consequently, a lot of time, effort and resources can be spent on ML systems that do not support the real world. Based on experience and expert inputs, Duke Energy has developed a hybrid model that combines the best of available analysis tools and ML systems to enable experts and technicians to focus effectively and access data, so they can make the most accurate decisions where needed, with fewer things slipping through the cracks.

Scientific ML

Duke's hybrid model methodology development occurred at the same time as biologists and other scientific groups were developing similar techniques and finding pure ML did not produce accurate results in practice. The hybrid approach is scientific machine learning (SciML), where actionable decisions are made based on reliable data supported by subject matter expertise.

SciML is noted for needing less data, being better at generalization, and being more interpretable and reliable than both unsupervised and supervised ML. Duke Energy's use of SciML went into effect in January 2019, while the terminology and papers on the concept from academic and commercial AI/ML platforms did not come into common use until later 2019 and 2020.

Experts are regularly asked by the asset and finance group to provide a list of transformers most likely to fail or in the poorest condition for a proactive replacement project. The response is regionally based, with various spreadsheets, different analyses and different collations, as some experts have more than 1000 transformers to evaluate. Then a call comes in about a failed transformer that is not on any of the supplied lists. Such failures are inevitable: Not every failure is driven by condition-related failure modes, and not every failure is predictable.

The first step in the development of a useful health and risk management (HRM) tool was to invest in data cleanup and subsequent data-hygiene management. This is an ongoing task and requires constant vigilance to prevent rogue data errors from causing false positives in analyses. Data is made available through a single-user interface, and standard engineering algorithms are applied to identify issues and data needing deeper analysis. Condition-based maintenance (CBM), load variation, oil test, electrical test and work order data all provide context in one interface for decision support.

Analytics such as the Doble Frank scores, TOA4 gassing scores and severity, and Electric Power Research Institute (EPRI) PTX indices are applied initially, and the results are normalized as a linear feature set that can be analyzed with a supervised ML tool. The combination of approaches allows data related to each transformer to be classified into one of several predefined classifications or states: normal, monitor, service, stable, replace and risk identified.

The SciML tool takes the best of both worlds, applies standards and guidelines, and benefits from the broad application

of ML. The process at Duke Energy has reduced time for experts to perform annual fleet evaluations to a few days, rather than several weeks, in a consistent manner across the organization. The number of bad actors slipping through the cracks is lower, but not yet zero.

One of the features of the hybrid system is the ability of the system to change some states automatically:

- A state may be changed automatically to "monitor" or "service" based on raw data.
- The state may be changed to "risk identified" based on engineering analytics and ML classification.
- No transformer state can be automatically changed to "stable" or "replace," as those states require expert intervention. After reviewing the data, the expert determines whether a transformer is stable or should be marked for replacement, with comments recorded.

Duke Energy's hybrid model of engineered analytics and ML has proven to be an excellent but imperfect tool — far more accurate than either pure AI/ML tools or engineered analytics alone. The transformer state updated by experts is now far more useful in making sound planning decisions.

Success, in terms of uptake and use of the hybrid model, has been based on numerous activities: data hygiene, collation of data sources, application of standards and guidelines for engineered analytics, data normalization for features to feed the ML, continuous expert input and refinement in a closed-loop evaluation.

The hybrid approach has enabled experts and field technicians to focus on important and critical cases. The system is not perfect, but it has identified bad actors more consistently and more accurately than any previous approach used at Duke Energy.

The Calisto R9 dissolved gas analysis (DGA) monitor provides early detection of transformer health problems, enabling fault diagnosis and better asset management over the life of a unit. Photo by Doble.

Experts Are The Key

AI/ML tools can provide benefits in interpreting and classifying complex data, but they can be fooled by data that is inconsistent with their training set. ML tools require input from experts who can guide tool development in specific applications.

Understanding the raw data and making the best use of data-hygiene and data-management activities is a base for building an overall analysis system that combines best practices, application of standards and guidelines, and targeted use of AI/ML systems. Doble Engineering has shown developing targeted AI/ML tools can bring benefits to practical data analysis in the field and applying targeted ML tools can support experts in their asset performance analyses. TDW

Acknowledgments

The authors would like to thank their colleagues at Duke Energy, Doble Engineering Co. and many more across the industry who have provided comments, feedback and discussion of the application of AI techniques. Many thanks to Dr. Mitiche at Glasgow Caledonian University for sharing her results of AI analysis of PD/EMI data.

This article was provided by the InterNational Electrical Testing Association. NETA was formed in 1972 to establish uniform testing procedures for electrical equipment and systems. Today the association accredits electrical testing companies; certifies electrical testing technicians; publishes the ANSI/NETA Standards for Acceptance Testing, Maintenance Testing, Commissioning, and the Certification of Electrical Test Technicians; and provides training through its annual PowerTest Conference and library of educational resources.

This article is published in tribute to Tom Rhodes who sadly passed away recently.

DR. TONY MCGRAIL of Doble Engineering Company provides condition, criticality, and risk analysis for substation owner/operators. Previously, he spent over 10 years with National Grid in the UK and the US as a Substation Equipment Specialist, with a focus on power transformers, circuit breakers, and integrated condition monitoring. Tony also took on the role of Substation Asset Manager to identify risks and opportunities for investment in an ageing infrastructure. He is an IET Fellow, past-Chairman of the IET Council, a member of IEEE, ASTM, ISO, CIGRE, and IAM, and a contributor to SFRA and other standards.

TOM RHODES graduated from the Upper Iowa University with a BS in professional chemistry. He had over 30 years of data analysis for asset management of industrial systems. Rhodes worked as Implementer/Project Leader at CHAMPS Software implementing new CMMS/asset management technology, and held titles of Sr. Science and Lab Services Specialist, Scientist, and Lead Engineering Technologist at Duke Energy.

BY **ROBBY SIMPSON**, DER SECURITY CORP.

A Look At IEEE Standards For DERs And The Grid

With the growing use of distributed energy resources comes growing considerations in cybersecurity, communications and interconnections.

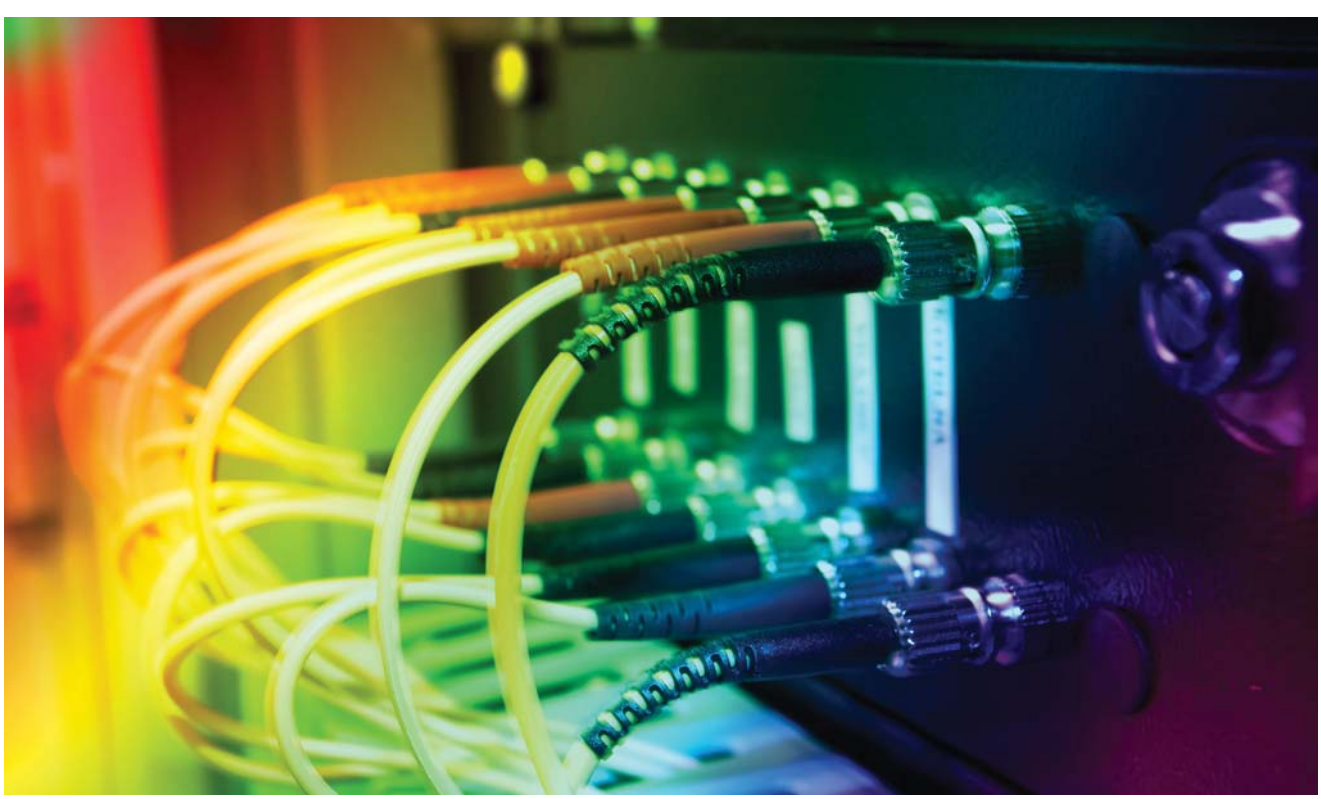
For several years, the energy and utilities sectors have been undergoing a fundamental shift from a system dominated by a few central power plants to a more decentralized energy infrastructure. The process by which energy is generated, transmitted and distributed has continuously evolved to include a mix of dispersed, low-carbon and renewable energy sources such as solar, wind, battery storage, microgrids and even electric vehicles. Collectively referred to as distributed energy resources (DERs), the energy industry has seen a rapid increase in the deployment and integration of DER technologies within electric power systems. This transformation is driven by a global push for countries to decarbonize their electric production systems, broader energy production and consumption sectors to make the global energy industry more sustainable.

The growing deployment of DERs means there also is a growing need for standards that address the integration, communication, management, functionality and cybersecurity of DER technologies — all of which are pivotal for safe and effective use within electric power systems. The Institute of Electrical and Electronics Engineers Standards Association (IEEE SA) is at the cutting edge of developing such standards that address the communications, interconnection and cybersecurity of DERs, in tandem with the rapid innovations being made within these areas.

A Paradigm Shift

Before DERs rose in popularity and most of the energy generation was centralized, energy production systems could communicate with the grid through private networks, like supervisory control and data acquisition (SCADA) networks. This lessened the focus on rigorous cybersecurity and communication standards, as communications and operations were done on private networks, not shared with other users and applications.

In the last few years, the utility industry has been required to manage growing aggregations of different DER technologies that are often remote or owned by consumers. This movement toward distributed generation, including non-utility assets like



Many DERs deployed in the past either did not have communication capabilities or used proprietary communications where there was limited ability to understand if they met various requirements or provided the cybersecurity protections needed. Photo by Spfotocz, Dreamstime.

The IEEE 2030 Series standards discuss the smart grid encompassing the integration of power, communications and information technologies of DERs for an improved electric power infrastructure. Photo by Elena Elisseeva, Dreamstime.

electric vehicles and microgrids, has caused a paradigm shift in communications for the grid from traditional private networks to the public internet.

Cybersecurity Guidelines

While providing more sustainable energy generation options, using DERs with management systems that communicate with electric power systems and optimize grid dynamics through the public internet has created a growing need for strong cybersecurity standards and practices. For example, the IEEE SA Distributed Generation, Energy Storage and Interoperability Standards Committee (SC21) is working on the IEEE P1547.3 Draft Guide for Cybersecurity of Distributed Energy Resources Interconnected with Electric Power Systems, which provides guidelines for the cybersecurity of DERs and their interconnection with electric power systems.

The IEEE P1547.3 guide does not define any new protocols or standards, per se, but rather provides details on how already existing protocols and standards should be used to create secure DER systems. These standards are necessary to combat possible cybersecurity issues that may arise. Such issues could result in not only an inconvenience but also physical damage to the grid and associated safety consequences that would occur if there were a loss of power.

Open Standards

In tandem with the cybersecurity considerations of DER technologies, the industry is beginning to focus on the evolving interconnection and communication standards of DERs and electric power systems. The industry has seen a movement toward the use of open standards in the DER space, driven largely by the adoption of the IEEE 1547 Series and, more specifically, IEEE 1547-2018.

IEEE 1547-2018 focuses on technical specifications for the interconnection and interoperability of the associated interfaces of DER technologies with the utility electric power systems with which they are connected. The standard provides requirements relevant to the function of DER interconnections, including performance, operation, testing, safety considerations and maintenance, which have become increasingly more relevant as DERs have evolved and the number of DERs has rapidly increased. There also is a necessity for uniformity among DER interconnections, including general requirements, response to abnormal conditions, power quality, islanding, and test specifications and requirements for the design, production, installation, evaluation and commissioning of DERs — all of which are defined in the standard.

The rapid growth of DERs, especially consumer owned, has made stated requirements universally needed for industry-wide interconnection of the resources, including synchronous machines, induction machines, and power inverters and converters. These components are crucial to the installation, interconnection and, importantly, communications between DERs and utilities that enable their use.

Communications Evolution

Many DERs deployed in the past either did not have communication capabilities or used proprietary communications where there was limited ability to understand if they met various requirements or provided the cybersecurity protections needed. As open standards that rely more and more on traditional internet technologies that have stood the test of time are beginning to be used, the industry is moving away from utility- and grid-specific technologies and toward more widely adopted technologies and standards. This evolution has made the interconnection of DERs more efficient, as these processes have become standardized and the digital asset management systems and software needed for

interconnection, communication and control have become universal.

Closely related to these interconnection advances, the industry also is seeing an evolution in communication protocols and standards for DER technologies and their operating systems. The biggest driver of this evolution is partly due to the shift from private networks to the public internet and the move away from grid- and utility-specific technologies in favor of more widely adopted ones.

With many DERs now using information technologies that connect with the grid over the public internet, there is a need for efficient and standardized communications between the systems that facilitate their interconnection. The IEEE 2030 Series standards discuss the smart grid encompassing the integration of power, communications and information technologies of DERs for an improved electric power infrastructure. In particular, the series defines the communication protocols and their operation between DERs and elements of the smart grid that will be critical to a successful DER infrastructure that serves load while providing for ongoing evolution of end-use applications.

Many DERs deployed in the past either did not have communication capabilities or used proprietary communications where there was limited ability to understand if they met various requirements or provided the cybersecurity protections needed. Photo by Spfotocz, Dreamstime.

Internet Standards Alignment

An important standard in the IEEE 2030 Series is IEEE 2030.5-2018, which defines the communication protocol between operators, utilities and non-utility assets, such as DERs and other grid-connected devices such as electric vehicles. Aligned with the shift to the public internet for communications, IEEE 2030.5-2018 is developed using widely adopted internet standards that are familiar and proven — most notably, the transmission control protocol/internet protocol (TCP/IP) suite and the hypertext transfer protocol (HTTP), a standard that defines how resources are exchanged over the internet and underpins the World Wide Web.

Finally, another internet standard that has become crucial for the cybersecurity of DER is transport layer security (TLS). It is used by IEEE 2030.5-2018 to provide a variety of cybersecurity functions, such as authentication, authorization and confidentiality. When combined as in IEEE 2030.5-2018, TLS and HTTP make up the familiar HTTPS used by virtually all secure web infrastructure today.

Thus, IEEE 2030.5-2018 combines standards like TCP/IP, HTTP and TLS with industry best practices and application semantics to provide multiple options for communications between DER smart energy systems and utility management. Specifically, the well-defined profile of standards in IEEE 2030.5-2018 enables management of the end-user energy environment. This includes demand response, load control, pricing, metering, and management of distributed generation, electric vehicles and so on.

The standard also defines the mechanisms for exchanging application messages, the exact messages exchanged, including error messages, and the security features used to protect the application messages exchanged between the non-utility systems and utility/grid management. The security features needed to protect these application messages are where the realm of cybersecurity and communications for DERs and utilities intersect. As such, IEEE 2030.5-2018 specifies a variety of requirements related to cybersecurity while maintaining usability such as a modern default cipher suite, access control recommendations, as well as certificates and associated keys for both servers and clients.

Increased Considerations

Standards like IEEE 2030.5-2018 and the rest of the IEEE 2030 Series have been instrumental to the adoption of standardized practices that successfully enable communications between DER asset management systems and the smart grid. As the consumer use of electric vehicles and electric vehicle chargers grows, standards like IEEE 2030.5-2018 will start to be utilized and further developed for establishing vehicle-to-grid energy-transfer protocols.

As work continues toward a more sustainable future through DERs and non-utility assets, the energy industry can expect to see increased cybersecurity, communication and interconnection considerations for DER management systems and the energy grid — as well as the need for updated standards and people who can develop them.

To learn more about DER trends or become involved in IEEE SA's energy and utilities work, visit the IEEE SA Energy page. TDW

ROBBY SIMPSON (*robby.simpson@ieee.org*) is a Senior Member of IEEE and chair of the IEEE 2030.5 Standards Committee. He also is a member of the COM/PLC – Power Line Communications Standards Committee and a member of the IEEE Standards Coordinating Committee 21, which oversees IEEE 1547. In the past, Simpson was a member of the IEEE SA Board of Governors and chair of the IEEE SA Corporate Advisory Group. Before starting his career, he earned his bachelor's degree in computer engineering from Clemson University and a Ph.D. in electrical and computer engineering from the Georgia Institute of Technology. Simpson is currently the CTO of startup DER Security Corp., focusing on enabling secure communications with DER.

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Digger Simulator

CM Labs Simulations, a vendor for simulation-based training in the construction and ports industries, has announced the release of the Digger Derrick Simulator Training Pack. It accurately replicates machine stability and engine behavior, resulting in effective, efficient operator training. The Training Pack supports organizations in the utility market addressing industry issues such as operator safety, sustainability and equipment maintenance. Incorrect outriggers handling or misuse of auger and boom can result in risky operation, injury or equipment tipping. CM Labs' Digger Derrick Training Pack offers a safe, effective and comprehensive alternative for training while mitigating the increased fuel costs and wear and tear that typically result from inexperienced handling.

The Training Pack's progressive learning exercises gradually build skill and confidence and include lessons that help prepare for certification testing, such as the Electrical Industry Certifications Association (EICA) crane exam. Trainees work on skills such as controls familiarization, and auger and pole control and setting. Performance metrics tracked during training exercises include safety violations and fuel efficiency. Applying CM Labs' proprietary Smart Training Technology, the simulation accurately replicates machine behavior—providing real-world training opportunities to help improve safety and reduce the risk of accidents. Users gain an understanding of engine actions and machine stability during drilling and pole setting. Better understanding of the hydraulics, boom backlash and deflections, tipping behavior, and cable and hook during drilling and pole setting, combined with the earth (ground) simulation ensure safe and efficient maneuvers. The training pack replicates true engine vibrations and sounds, including hydraulics, variable RPMs, drilling, horns and crane overload alarms that are important audio cues for safe operation.

The Digger Derrick Training Pack is compatible with all of CM Labs' Vortex Simulators, including the desktop Vortex Edge Plus, the motion-enabled Vortex Edge Max, and the high-immersion Vortex Advantage. The simulator training is part of CM Labs' range of lifting machines, making it suitable for training centers or organizations in the utility market.

CM Labs | *www.cm-labs.com*

Guard Arm

The new Fork-Mounted Guard Arm from LineWise helps prevent conductors from falling into the right-of-way crossings. Designed to conveniently mount to the pallet forks on a telehandler, the Guard Arm provides a simple, yet effective safety measure to securely catch falling lines. Featuring a 1,200-lb capacity, the LineWise Guard Arm has a 12-ft-wide span from tip to tip with the ears installed, allowing it to accommodate a variety of distribution lines. When not in use, the ears can be easily stowed on the unit to maintain a more compact profile. The Guard Arm also includes a cross roller with bearings to facilitate movement if a conductor lands on it. The Guard Arm can be installed or detached in about 30 seconds with no adapter needed. A rear locking pin, which meets OSHA requirements, securely holds the unit in place on the forks. The Guard Arm weighs 607 lbs (275 kg) and can be used on all telehandlers with a capacity of 8,000 lbs (3,629 kg) or greater. It has been officially approved for use on a variety of telehandler models from Xtreme Manufacturing, as long as the operator understands and follows the appropriate load ratings for the machine.

LineWise | *www.line-wise.com*

Rugged Field Computing

Getac Technology Corp. has launched its next-generation UX10 tablet and V110 laptop – two powerful, yet portable, fully rugged devices designed to thrive in challenging work environments. Both the UX10 and V110 boast 12th Generation Intel Core Processors, expanded memory and increased storage options, as well as extensive I/O and connectivity options (including 5G), making them two of the most advanced rugged devices Getac has ever produced.

For the UX10, key features include a choice between powerful 12th Generation Intel Core Processors and Intel Pentium Gold Processors, to suit different applications, and a LumiBond touchscreen boasting 1,000 nits of brightness. Additionally, 8GB of DDR4 RAM (with option of up to 32GB), and a 256GB PCIe NVMe SSD (with option of up to 1TB) deliver computing capability. Upgraded connectivity features include Bluetooth 5.3, Intel Wi-Fi 6E AX211, Thunderbolt 4 Type-C, and optional 4G LTE or 5G Sub-6 support, to keep individuals and teams connected in even remote locations. Its lightweight design makes the UX10 easy to carry and operate for long run times, while IP66 and MIL-STD-810H certifications, drop resistance up to 6ft and an operating range of -29°C to +63°C (-20°F to 145°F) ensures optimal functionality in even adverse weather conditions.

The V110 laptop features a powerful 12th Generation Intel Core Processor and Intel® Iris Xe graphics, alongside an 11.6" LumiBond touchscreen boasting 1,000 nits of brightness. The next-generation V110 fully rugged laptop is designed to make complex field tasks easy. Dual hot-swappable batteries as standard extend operation between charges, while optional 64GB DDR4 + 2TB storage supports intense data activities, such as planning and execution of ground/aviation logistics support in the defense industry. Its versatile form factor also means workers can quickly switch between touchscreen and keyboard-based inputs depending on the task at hand..

Getac | *www.getac.com*

Transformer Monitor

Franklin Electric has expanded its power grid monitoring product line with the launch of the INCON Distribution Transformer Monitor (DTM). The DTM provides, meter-grade monitoring of high-value, mission critical, low voltage pad mount transformers and conventional pole top transformers. By continuously monitoring the key indicators of a transformer's performance, the DTM provides remote access to real-time transformer health data and automated alarms for condition-based maintenance planning.

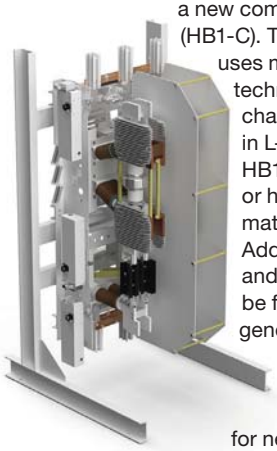
A built-in cellular modem allows the DTM to communicate via a cellular network enabling utilities to deploy DTMs virtually anywhere and at scale. A secure MQTT communication protocol allows the DTM to safely communicate with Franklin Electric's web-based asset management database, UNITE. This IoT database features data visualization tools that provides user-friendly access to all distribution transformer performance data for analysis and reporting in a centralized location.

With the INCON DTM, utilities can manage maintenance and truck rolls by exception with customized threshold alarms and notifications, determine the most efficient distribution of power during peak times, and ensure the delivery of high-quality outbound power when their customers need it the most.

Franklin Electric | *www.franklingrid.com*

Generator Circuit Breaker

Siemens is expanding its generator circuit-breaker portfolio with a new compact version - the HB1-Compact (HB1-C). The versatile and customizable solution uses maintenance-free vacuum switching technology and addresses the most challenging of constraints. Available in L-shape and I-shape designs, the HB1-C can be mounted either vertically or horizontally and can be adjusted to match existing busbar connection points. Additionally, the generator circuit-breaker and its integrated main disconnector can be fitted with earthing switches on the generator side and/or the transformer side for greater flexibility.



These customizable features make the HB1-C not only suitable for new applications, but also valuable for retrofit scenarios in power plants where security of supply is essential, and space is often limited. With increased focus on renewable power and cost reduction front of mind, reliable protection technology is crucial. Generator circuit-breakers are vital components for improving the reliability and availability of power plants. Their installation not only protects equipment such as generators and transformers against overload or short circuiting, but also provides high availability, simplified operational procedures and a reduction in costs.

Siemens | *www.siemens.com*

Mobile Workforce Management

ARCOS LLC has launched two new products for building the digital utility of the future. The first is ARCOS Mobile Workbench for Construction, which replaces paperwork, phone calls and emails with a digital collaboration hub that utility employees can open anywhere to design, construct, manage, and close out capital projects. The second new product announced by ARCOS is Utility Insight, which gathers and analyzes data from across a utility and creates a set of "work views" that includes information from ARCOS and any other IT platforms.

Another critical building block for the utility of the future is ARCOS's Utility Insight platform. Utility Insight integrates and complements ARCOS solutions such as Mobile Workbench, Callout and Crew Manager to connect field and back-office staff for safe, efficient and reliable operations. Utility Insight pulls, caches, and analyzes data from virtually any source (e.g., OMS, GIS, AMI, etc.) and then delivers near real-time, actionable intelligence via easy-to-use dashboards for workers in the control room and field when and where they need it. Unlike traditional dashboard tools, Utility Insight enables users to easily act from the same interface – such as initiating a callout or sending a notification to a field user through the ARCOS Mobile+ app.

ARCOS LLC | *www.arcos-inc.com*

Safety Platform

Hastings has released its new Safety Platform to give lineworkers additional on-the-job support. The lightweight, polyethylene platform supports up to 300 pounds and provides extra protection when working from the ground, pulling conductors, or when working near energized equipment. The heavy non-skid surface on top prevents slips, and the extra-large legs with non-skid bases prevent tipping or skidding. It also features sturdy handles built-in on all four sides, making it easy to carry and transport. The unicellular polyurethane foam that fills the inside provides a strong yet lightweight surface. Dimensions are 24 inches wide by 30 inches long by 12 inches high. For maximum protection, the platform must be kept free of dirt, dust, or contamination.

Hastings | *www.hfgp.com*

Digital Twin Platform

Bentley Systems, Incorporated has announced new capabilities of its iTwin Platform, extending the scope and interoperability of infrastructure data that engineering firms and owner-operators can use to create and leverage digital twins in design, construction, and operations workflows. The new iTwin Platform capabilities will power Bentley Infrastructure Cloud, a set of solutions that span the end-to-end infrastructure lifecycle and value chain, encompassing ProjectWise, SYNCHRO, and AssetWise, unified and made interoperable by Bentley's infrastructure schemas.

iTwin Experience is a new cloud product to empower owner-operators' and their constituents' insights into critical infrastructure by visualizing and navigating digital twins. Significantly, iTwin Experience accelerates engineering firms' "digital integrator" initiatives to create and curate asset-specific digital twins, incorporating their machine learning, analytics, and asset performance algorithms.

Bentley Systems | *www.bentley.com*

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Baltimore Gas and Electric
We ❤️ our sister utilities, ComEd, PECO and Pepco Holdings. Thanks for sharing resources when we need them and working alongside us to serve our communities. Happy #NationalSiblingsDay, Exelon family!

Tennessee Valley Authority
A rare look deep inside Norris Dam! Our highly trained hydro plant technicians and engineers inspect the Unit 1 penstock and scroll case, a spiral-shaped intake that regulates how much water flows to the turbine. Normally 24,000 gallons of water per second would be pulled through the unit when generating.
Unit 1 is offline and undergoing maintenance and upgrades.

We are PROUD of our teams for training hard and representing CPS Energy at this year's American Public Power Association (APPA) Lineworkers Rodeo. 🙌

Austin Energy @austinenergy
Curious cat Rosie had climbed up a tree high above her house, but was unable to climb back down 🌳 Her family noticed an Austin Energy truck in the area and asked the crew if they could help resolve the cat-astrophe: beloved Rosie had been stuck in the tree for four days! 😿

Pedro Pizarro
President and Chief Executive Officer at Edison International (EIX)
I was driving through San Marino on the way home to Pasadena and saw Southern California Edison (SCE) trucks so stopped to say hello. Anthony Bizoso and other crew members were hard at work — safely — on a Saturday afternoon replacing a pole. Thanks to them and all the crews working through this holiday weekend of Easter, Passover and Ramadan to keep our communities powered safely!

Pacific Gas and Electric Company
As expected, PG&E's most recent #snowpacksurvey shows an abundance of snow after months of storms. The California Department of Water Resources reports the overall California #snowpack is 237% of normal to date, reportedly the highest April average since 1952. That's good news for our more than 60 #hydroelectric #powerhouses, which produce clean, #renewableenergy.

AD INDEX

SALES CONTACTS

VP, Endeavor Energy Group
T&D World & Utility Analytics Institute
Mark Johnson
Phone: 720-371-1799
Email: mjohnson@endeavorb2b.com

Director of Sales and International Customers
David Blaza
Phone: 415-819-7440
Email: *dblaza@endeavorb2b.com*
T&D World, Utility Products, Utility Analytics Institute and Distributed Energy

Midwest U.S, ND, SD, NE, IA, MN, WI, MI, IL, IN, OH, KY, TN & Eastern Canada
Director, Business Development
Stephen M. Lach
Phone: 708-542-5648
Email: *slach@endeavorb2b.com*

Eastern U.S. GA, SC, NC, VA, WV, MD, PA, DE, NJ, NY, CT, RI, MA, NH, VT, ME
Hunter Ramirez
Phone: 303-946-3764
Email: *hramirez@endeavorb2b.com*

Western U.S. CO, NM, TX, AZ, CA, NV, UT, WY, MT, ID, OR, WA, HI, AK & Western Canada
Brent Eklund
Phone: 303-888-8492
Email: beklund@endeavorb2b.com

Sales Support Manager
Debbie Brady
Email: *dabrady@endeavorb2b.com*

International Linemen's Rodeo, T&D World Buyers Guide and Events
Sam Posa
913-515-6604
Email: *sposa@endeavorb2b.com*

Utility Analytics Institute Memberships
James Wingate
Membership Development Manager
(404) 226-3756
Email: *jwingate@endeavorb2b.com*
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Community Engagement Essential to Building Puerto Rico Grid Resilience

Daniel Kushner

Jeff Schlegelmilch

The electric grid is the very foundation of what makes civil society function and has been identified by FEMA as a community lifeline. This means that electricity, like water, fuel and transportation, are among the things that without which the rest of society does not function. But the grid is also at a crossroads with unprecedented funding to modernize and decarbonize the ways in which we power our lives. At the center of all of this are communities, each unique in their energy needs, disaster vulnerability, and capacities to cope with outages and energy price fluctuations. Because of this, community needs to be central to strategies for grid resilience and modernization.

The engineering aspects are often dictated by the physics of generating, storing, and moving electricity. But the demand that it serves is highly variable, and the importance of each electron's destination is outside of the purview of engineering and the laws of physics. From a technical perspective, it is crucial to ensure that all users have the power needed because it can be difficult to distinguish between levels of criticality. There are, however, situations, where we can identify the need for incremental levels of resiliency, particularly in the case of a disruptive event. For example, a grocery store that is the only one that serves the community and surrounding communities may itself be a critical lifeline. An area with higher rates of chronic disease burden may be more susceptible to health impacts from extreme heat in the aftermath of a disaster and subsequent outage. Solutions like infrastructure hardening, energy storage and microgrids can all help mitigate outsized impacts, but the right technology in the right location requires community input to help target these strategies.

There are tradeoffs in different approaches that also require community input. For instance, large-scale microgrids may take years to develop, design, fund, and build. It may be faster to consider back-up systems for key facilities, at least in the interim. Deployment of solar panels and other clean energy resources may be impacted by other investments in grid modernization.

Engagement in the Context of Puerto Rico

The importance of community is at the forefront in Puerto Rico. With a massive reconstruction of the grid underway, it is not just about replacing poles and lines, but re-designing how this lifeline serves the communities to which it is connected.

Hurricanes Maria, Irma, and now Fiona focused the attention of the nation on the impacts of a crumbling electric infrastructure on the economic, social, and physical health of Puerto Rico residents. After the initial shock of the effects of the hurricane dissipated, the underlying failures to maintain an effective grid are now even more painfully clear.

Every resident of the island sees the effects. The average resident experiences more than 10 outages annually, in contrast to those on the mainland who typically experience just over one. For businesses and residences, this leads to spoiled food and ruined inventory, raising costs and reducing revenues. Meanwhile, in 2019, electricity costs represented about 7% of the typical Puerto Rican's income, more than three times as those living on the mainland.

These deficiencies are the result of decades of underinvestment, lack of maintenance, strategic missteps, and brutal natural disasters. Meeting the task entails immediate response and long-term planning. In the short term, this is fixing broken devices. In the medium term, we need to redesign the grid to meet industry standards. Throughout the process, we need to proactively identify opportunities to use advanced technologies to provide innovative solutions.

LUMA is addressing these needs through infrastructure planning, but also through developing community engagement processes in order to co-develop ideas and strategies. LUMA is currently establishing partnerships for coordination for Integrated Resource Planning and engaging with universities, community non-profits, and other providers of essential services to develop strategies for deployment of new technologies. LUMA is executing STEM education programming with partners such as LEAP+E, including Impulsando tu Futuro, a project where LUMA's women engineers are teaming with groups of high school girls to build and race EVs. This engagement can help align efforts of community groups, government institutions, and the grid operator to provide higher levels of resiliency and sustainability for all.

The commitment to do this is just one more reminder that communities are also where grid operators' employees live their lives and build a future for themselves and their loved ones. Each is an ambassador to their community as well as a stakeholder in the impacts of the investments made into the grid. Employee engagement is as critical an investment as other aspects of grid resilience and modernization strategies.

This outreach is just the beginning. With grid investments meant to last generations, the community partnerships must also be developed well into the future through ongoing engagement, development of advisory boards, and creation of other mechanisms to ensure that community resilience is ultimately community centric.

As our electricity generation and delivery systems continue to evolve, the impacts of grid decisions on communities will continue to grow. Developing new models of engagement and collaboration with communities will help ensure mutually beneficial decisions amidst the unprecedented investments to build more resilience into our electric grid.

DANIEL KUSHNER is director of resiliency strategy, and **JEFF SCHLEGELMILCH** is a principal advisor at LUMA Energy.

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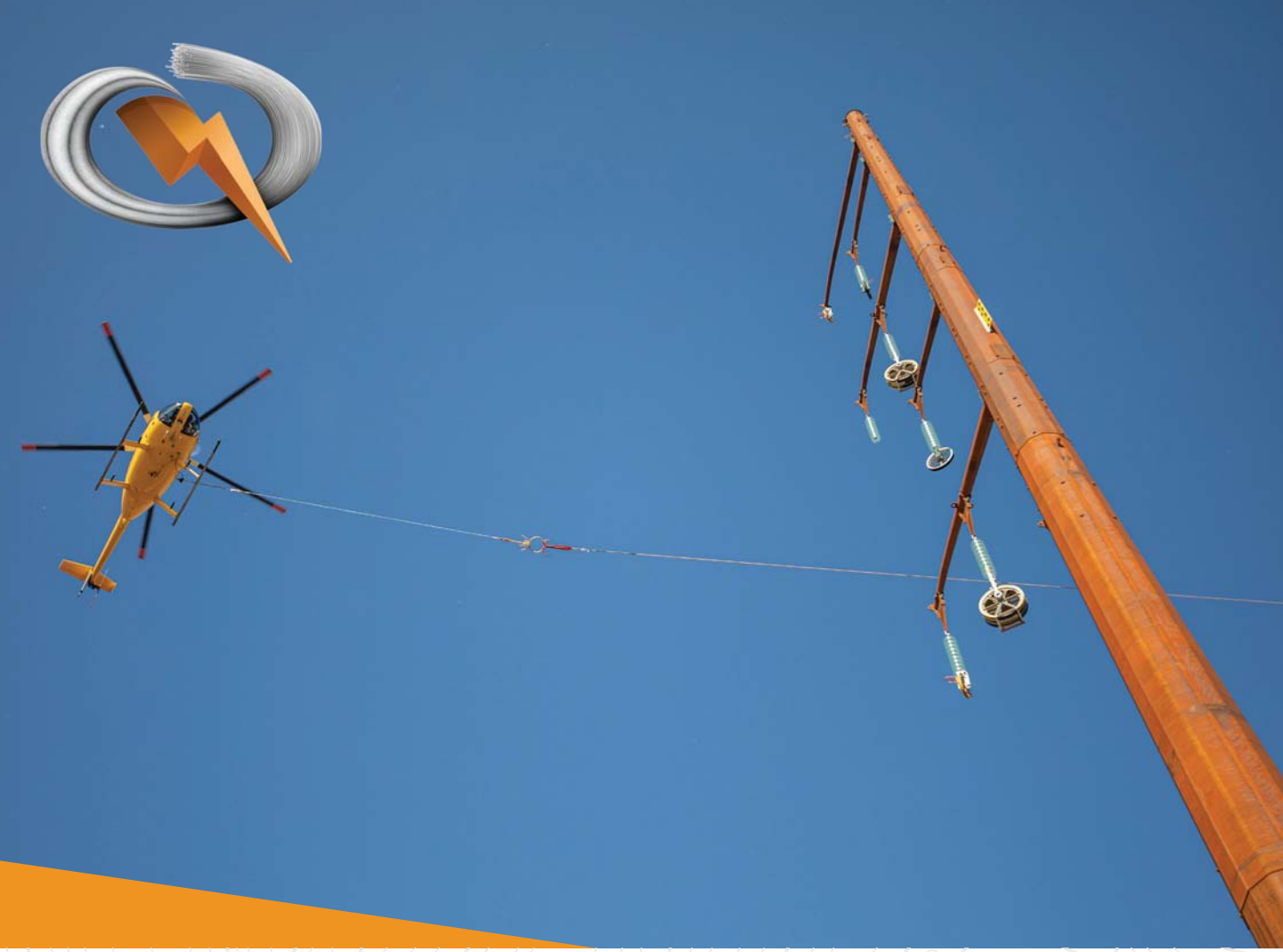

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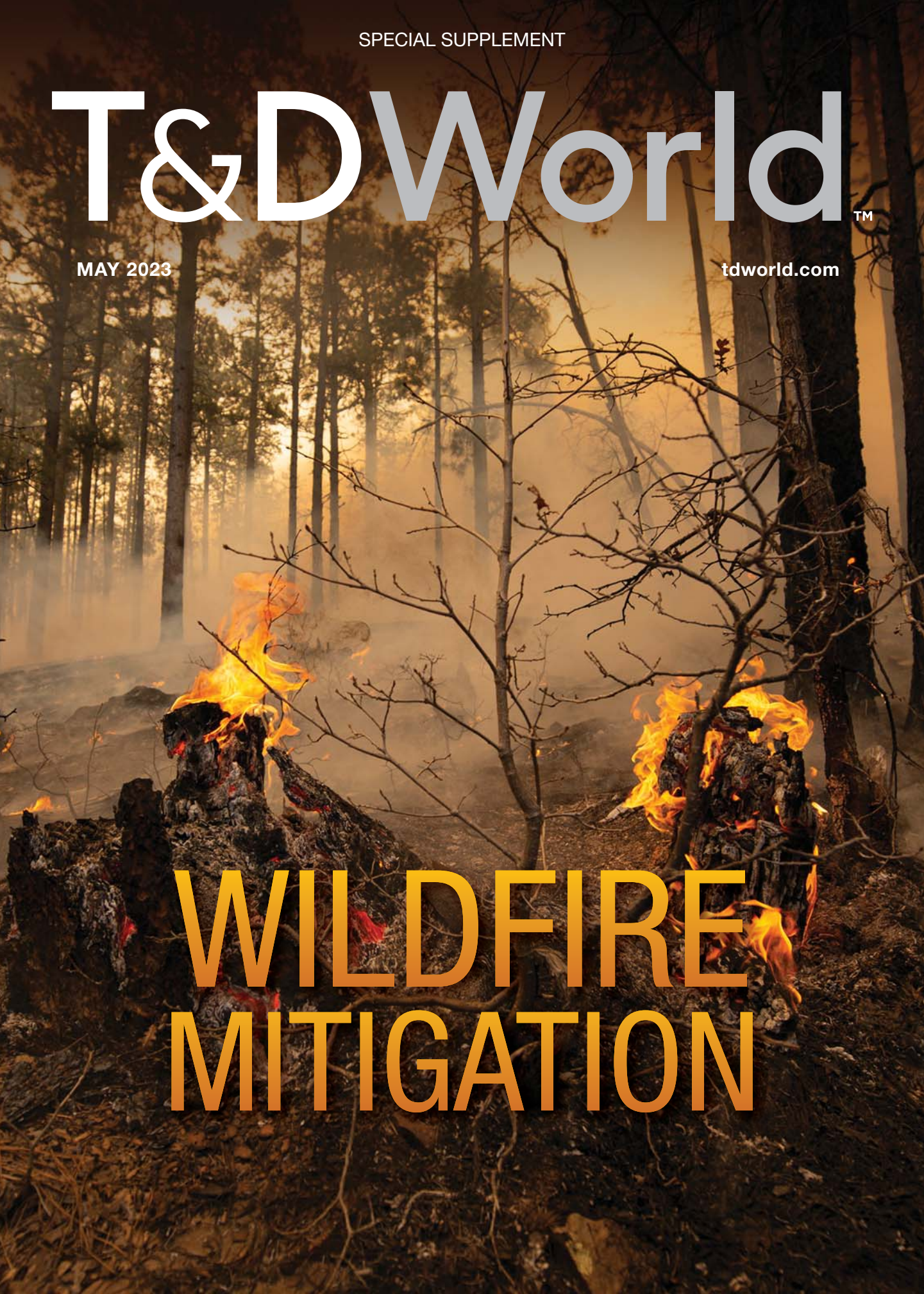

WILDFIRE MITIGATION

Spare the line, save a raptor

Avert outages and wildfires with FR-rated guards

1 in 10 wildfires are directly attributable to wildlife contact with energized equipment, according to California Utilities WMP in 2019. When developing effective fire mitigation plans, selecting wildlife guards that reduce the risk of wildlife contact and are also designed to meet the performance criteria of the IEEE Std 1656-2010 is critical.

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The Threat of Fires Widens, as Should Industry's Response

By **JEFF POSTELWAIT**, Senior Editor

As I'm writing this, legislators in my home state of Oregon are debating a bill to relieve some of the $3 billion in wildfire-related losses the state has seen since 2020. Further to the south, Californians are welcoming millions in federal funding to help communities prevent wildfires and fight them once they break out as part of the Biden administration's wildfire defense grant program.

Funding from that same $197-million program will be distributed across 22 states and seven tribes – some 100 communities in all, according to the *Los Angeles Times*. This comes on the heels of the $8.25 billion in wildfire management funding made available through the Bipartisan Infrastructure Law and announced this past July.

It's a cliché now on the West Coast to hear that fire now knows no particular season, and that fire season is, in fact, year-round. However, if the wide swath of the nation that the federal government saw fit to support with new funding is any indication, the danger of out-of-control fires devastating communities is present from coast to coast.

The U.S. Department of Agriculture keeps a list of wildfire projects under its purview. In Colorado's Archuleta County, home of segments of the San Juan National Forest, education programs will spread word about fire resistant construction. In the Blackfoot Watershed of Montana, "Fire Refugia" communities will be maintained so fires may pass without destroying homes or infrastructure. In Wyoming's Crooked Creek area, the landscape will be cleared to reduce fuel loads and restore the health of forests. In North Carolina, funding is granted to develop community protection plans and renew ones that expired.

The federal government's National Cohesive Wildland Fire Management Strategy has three parts: 1. Maintain resilient landscapes in accordance with land management objectives, 2. Create fire-adapted communities that can better withstand blazes without loss of life or property, and 3. Improve wildfire response across jurisdictions.

Utilities, too, are responsible for the communities in which they operate — not just in the sense of facing consequences when things go poorly as has occasionally happened, but in the sense of being a critical part of every community that requires electricity.

As I gathered and reviewed the materials we decided to include in this special annual wildfires supplement to *T&D World*, I heard from more utilities than in years past, which is a wonderful thing. We always strive to be a utilities-first publication, after all. But it is encouraging to me personally to see utilities taking this growing problem of wildfires as seriously as many are. We need community-minded utility leaders now more than ever, who see themselves as good stewards of their service territories and the people who live and work within them, as well as for the land itself.

Utilities from California, Arizona and Oregon sent us case studies on how they are using advanced sensors, meteorological equipment, remotely piloted drones armed with thermal cameras, integrated vegetation management techniques and other applications, all networked through powerful computers and occasionally applying artificial intelligence to sift through the massive pile of data generated to find signs of wear and tear or other trouble spots that might one day spark a fire. Because in severely dry and hot conditions, it is vastly easier to prevent a blaze than to fight one.

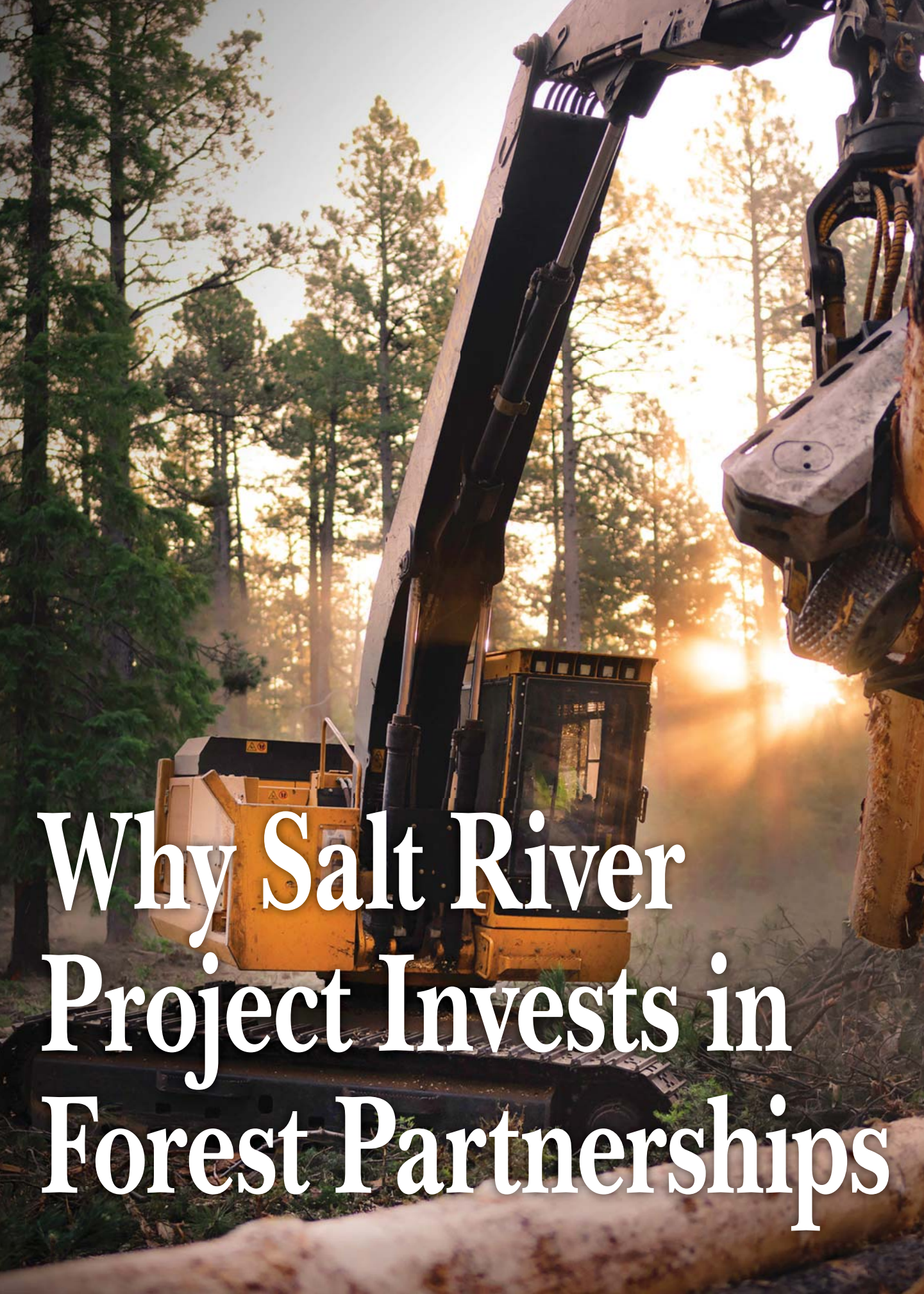
We also heard about the important role of land and water management, which can include things like clearing or thinning our land in strategic areas to minimize the impact of fires on infrastructure, buildings and other property. Utilities, consultants, vegetation management companies and wildfire mitigation firms are even beginning to learn from the traditional practices of Indigenous North Americans who used cultural burning to manage the lands they lived on for thousands of years before colonization by whites. This knowledge is being used by the U.S. Forest Service as well, which has adopted clearing of ladder fuels in heavily wooded areas that are at high fire risk.

Down the road from me at Oregon State University in Corvallis, the College of Forestry teaches these pre-Columbian techniques to students, and OSU's Extension Fire Program notes that controlled burns achieve a number of healthy forestry goals, including lowering wildfire risks, improving rangelands and encouraging native plant species and providing a healthy wildlife habitats.

With so much of the country under threat by wildfires, it is going to take a full spectrum of disciplines and techniques to combat the problem – some old and some brand new. The raison d'être for these supplements is to show that there are solutions for this problem readily at hand. They were developed by our finest minds and constructed with our most skilled people.

What we need now as an industry is to accept these tactics, techniques and technologies to meet the problem, and not to shy away from change. We have already seen the tragic consequences of putting off needed maintenance and saving money that would have been better spent on public safety measures.

Utilities are entrusted with a great responsibility, and it is up to utilities to show that the public faith in them has been well placed. TDW



Why Salt River Project Invests in Forest Partnerships

Salt River Project hires contractors to help strategically remove plants, parts of trees and other vegetation growing close to transmission lines. Photo by Salt River Project.

The utility works closely with partners to clear vegetation, perform strategic thinning, and pilot an early-warning wildfire detection system.

*By **PATTY GARCIA-LIKENS** and **ERICA ROELFS**, Salt River Project*

Over the last 10 years, Arizonans have watched as large wildfires ravaged a critical power corridor and watershed in the northern part of the state. The devastation has proven one important fact that must be addressed now: Arizona's forests are unhealthy.

About 120 miles (193 km) of Salt River Project's (SRP's) high-voltage power lines are located on forest service land located in northeastern Arizona. The lines deliver power to about 1.1 million people in the Phoenix metropolitan area. In addition, SRP provides water to about 2.5 million people in the greater Phoenix area.

Arizona's forested lands have been hit by devastating wildfires over the last decade and are primed for more infernos like those that have impacted California and Colorado. Many forested lands in northern Arizona have thousands of trees per acre, which can fuel large wildfires that are uncontrollable with catastrophic impacts.

Entire State Impacted

Wildfires not only devastate natural ecosystems, recreational areas and local communities, they also degrade water quality and resiliency and can interrupt power delivery if transmission lines are impacted.

Fires near power lines can affect power delivery by damaging lines and transmission towers while smoke and debris also can create a disturbance. After a wildfire, rainfall washes ash and debris into rivers and reservoirs. Then that material washes into SRP's reservoirs, reducing water storage capacity and damaging water infrastructure.

This is concerning because residents of the Phoenix metro area live in a desert environment, where reliable water and power are crucial. Furthermore, a recent study by the Electric Power Research Institute found that costs associated with a catastrophic fire can run up to hundreds of millions of dollars.

Forest 500 Project

To ensure reliable power for its customers, every five years, SRP crews conduct the Forest 500 project, which identifies trees and other vegetation that pose a risk to the utility's power system. SRP hires contractors to help strategically remove plants, parts

During wildfire season, if tall vegetation is not removed, low vegetation can ignite the taller vegetation, forming fuel ladders that bring flames closer to the taller trees and overhead power lines. Photo by Salt River Project.

SRP also conducts vegetation management activities in residential areas as part of its Right Tree Right Place program. Photo by Salt River Project.

of trees and other vegetation growing close to transmission lines. The effort is done in coordination with the Bureau of Land Management as well as state and private land between the forests where brush must be cleared.

During wildfire season, if tall vegetation is not removed, low vegetation can ignite the taller vegetation, forming fuel ladders that bring flames closer to the taller trees and overhead power lines. SRP has been clearing hazardous vegetation since 1996 to improve the health of forests as well as power reliability in the greater Phoenix area.

"Our first priority is bringing reliable energy to our customers," said EJ Cochrum, a utility forester for SRP. "And we want to keep wildfires down. Without the mitigation and clearing efforts we partake in every five years for the Forest 500, we may not be able to ensure the same power reliability to our customers."

SRP also conducts vegetation management activities in residential areas as part of its Right Tree Right Place program. The program removes trees threatening safety and power reliability in cities across the Phoenix metro area.

For each tree removed under the Right Tree Right Place program, SRP plants as many as three more trees in safer, more appropriate areas.

Smoke Detector Pilot Project

In 2023, SRP also is piloting a Smoke Detector project that acts as an early-warning system for wildfires that occur near the utility's transmission line towers in the Tonto and Apache-Sitgreaves national forests. The project uses cutting-edge camera and smoke detector technology to capture physical changes on the utility's 500-kV transmission towers that transmit energy to SRP's customers from power plants located in eastern Arizona.

SRP is setting up two test areas with 12 cameras to capture images of a portion of the 500-kv transmission towers every 10 minutes. The solar-powered infrared cameras can work at night and capture images up to 10 miles (16 km) out with a 360-degree view.

Through artificial intelligence, the cameras learn the surrounding environment, report changes and provide alerts when identifying smoke from wildfires or changes to structures. Cameras also can alert SRP to issues such as downed lines, downed towers and damaged equipment.

The cameras are planned to be up and running by May 2023, just in time for forest fire season.

"Today, if a fire impacts our lines, we may not know until we get an alert that something has interrupted the delivery of power. Our crews could be up to 200 miles [322 km] away and have no visuals to determine what is happening," said Floyd Hardin, SRP fire management officer. "With this tool, we have the potential to see images nearly in real time and can determine our next steps quickly and efficiently."

Strategic Thinning

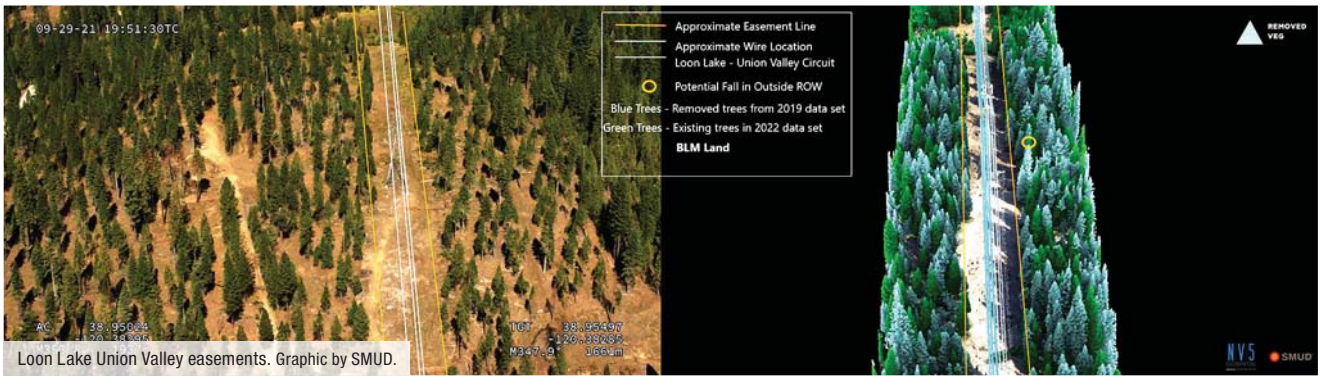
For water resiliency and reliability, SRP also is partnering with the U.S. Forest Service, Arizona cities, towns, counties and other organizations to help prevent the devastating impacts from wildfires by strategically removing small trees that will enable healthier trees to thrive. Preventive strategic thinning will not only improve the health of forests and watersheds but also reduce the need to reforest large sections of our forests.

Thinning the forest not only helps with power and water reliability, it also offers the added benefit of providing rural jobs, increasing infrastructure and equipment investments, and helping to drive rural economic development opportunities.

Through artificial intelligence, the cameras learn the surrounding environment, report changes and provide alerts when identifying smoke from wildfires or changes to structures. Photo by Salt River Project.

As the Phoenix metro area continues to grow and thrive, it is critical for SRP to provide sustainable and reliable power and water. A lot can be learned from the wildfires that have ravaged Arizona, and SRP is acting on those lessons now. With support from partners, industry and researchers, the utility is building the tools needed to reach its forest health goal. TDW

PATTY GARCIA-LIKENS (*patty.likens@srp.net*) and **ERICA ROELFS** (*Erica.roelfs@srpnet.com*) are media relations representatives covering the subject matter areas of water and power on behalf of Salt River Project (SRP) in Arizona. SRP is a community-based, not-for-profit public power utility and the largest electricity provider in the greater Phoenix metropolitan area, serving approximately 1.1 million customers. SRP provides water to about half of the Valley's residents, delivering more than 244 billion gallons of water (750,000 acre-feet) each year, and manages a 13,000-square-mile watershed that includes an extensive system of reservoirs, wells, canals and irrigation laterals.



Loon Lake Union Valley easements. Graphic by SMUD.

Lower Risk Of Wildfires Along T&D Systems Long Term

To achieve the lowest level of risk, some utilities like Sacramento Municipal Utility District are embracing the practice of managing vegetation to tree height.

*By **ERIC BROWN**, Sacramento Municipal Utility District, and **NIEL FISCHER,** JH Land*

The catastrophic fires that have struck the U.S. states of California, Oregon, Washington, Colorado, New Mexico and Arizona in recent years are proving to be part of a new era and no longer isolated occurrences. While not as prominently reported, this theme has been repeated throughout the West, including Idaho, Wyoming, and Montana.

When catastrophic fires occur, it is evident the fire-risk regime utilities operate in has changed significantly. Utility vegetation managers must fully assess and comprehend the risks and how quickly risk is changing to be successful in managing infrastructure and vegetation to protect it from fire and ensure ignition risks are removed from the system.

Western Fire Risk

As Western droughts persist and vegetation continues to be inadequately managed across the landscape, pandemic population shifts have complicated the risk equation. According toa study published on Dec. 8, 2022, in the Frontiers in Human Dynamics journal, Flocking to Fire: How Climate and Natural Hazards Shape Human Migration Across the United States, more people call the interior West their home now, and the result has been an expanded wildland-urban interface (WUI), significantly increasing the population and number of structures at risk from wildfire.

For example, in Santa Fe County, New Mexico, where about 155,000 people reside, more than 34,000 private properties are at high risk of catastrophic fire, according to the Insurance Journal. So, even though New Mexico does not have as large of a population as California, a high proportion of its population is at risk.

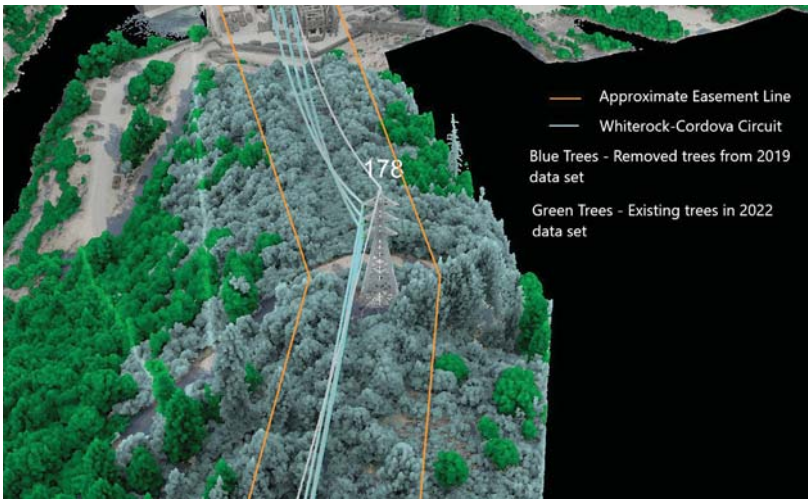
This population expansion into rural areas further complicates fuel treatment where a century of fire suppression and management policies has resulted in a highly combustible buildup of dead and live fuel. Utilities also are under increased pressure to provide highly reliable electric service to meet the demand of the shifting population of remote employees working from their homes.

While no one can put a value on life, there are quantifiable costs to loss of structures and fire suppression. For example, 2021 marked the most expensive year for annual federal suppression, with costs nearing US$4.5 billion, according to the National Interagency Fire Center. Property values have risen dramatically, with some Western states experiencing 40% increases in property value since summer 2020, according to the U.S. Census Bureau and U.S. Department of Housing and Urban Development. As property values have dramatically increased in some Western states, it is presumed that costs associated with fire risk will only increase in future fire events. The values associated with fire risk today are vastly different than those from merely two years ago.

Utility-caused fires have been exceptionally destructive to life and property in recent years. Despite utilities' efforts to manage grow-in risk and hazardous trees, danger-tree failure-related electrical ignitions continue to occur — with devastating impacts. Consider the Dixie Fire in California that raged across five counties from July 13, 2021, until it was declared contained

on Oct. 24, 2021. All told, more than 963,000 acres (389,712 hectares) burned, with one fatality and about 1500 structures lost. The fire was the first to cross the Sierra Nevada — and it did so twice. The cause of the Dixie Fire is alleged to have been a tree failure resulting in contact with energized conductors.

Across the West, regulators have begun requiring utilities — from the largest investor-owned utilities to the smallest electric cooperatives, to document and submit their plans to reduce wildfire risk. Where this has not occurred yet, it is likely to soon and with good reason — because the risk of a catastrophic wildfire occurring and the losses associated with a fire have both increased dramatically, not to mention the significantly increasing insurance premiums.



Whiterock Cordova change detection LIDAR. Graphic by SMUD.

Utility Fire Risk

For utilities, wildfire risk is essentially made up of two components:

1. Ignition risk, or a fire caused by the utility's assets
2. Carry risk, or the risk to the utility's infrastructure when a fire threatens that infrastructure while being carried by adjacent fuel and weather regimes.

Fire contains three basic elements: heat (ignition source), fuel and oxygen. Utilities can manage vegetation to control two of these elements, a heat source and fuel, near utility infrastructure. In other words, ignitions occur when a heat source contacts fuel. Utilities can prevent this from occurring in two ways through vegetation management practices:

1. Prevent infrastructure failure (engineering solution), including tree-caused infrastructure and equipment failure
2. Reduce the likelihood of ignition by removing fuel around the infrastructure in the event a failure occurs.

Going a step further, utilities also can control fuel around or adjacent to infrastructure — mostly vegetation in the West — to protect the infrastructure and nearby communities from an advancing fire.

Two Approaches

One approach to vegetation management is to make decisions following a risk management framework. Determining which vegetation to control is site specific, but the good news is numerous data sets are available and becoming less expensive over time, including remote sensing, light detection and ranging (LiDAR) and other emerging technologies.

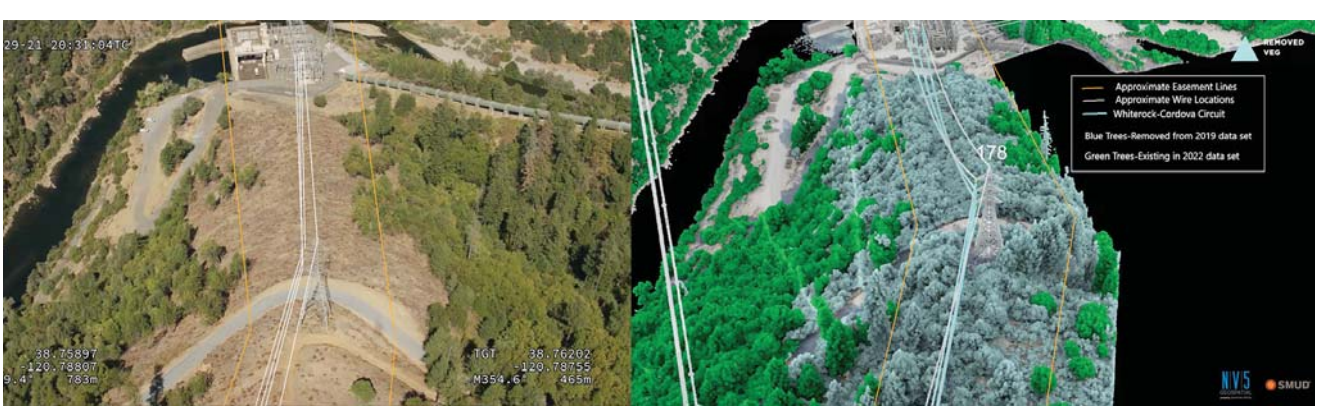
The data sets provide objective information about vegetation and its proximity to infrastructure, but the management decision to apply prescriptions rests with decision makers after evaluating qualitative information and risk tolerance.

A second approach is to manage vegetation to tree height to achieve the lowest level of risk. All vegetation within strike height is removed. Some utilities are embracing this approach, which seemed far-fetched only five years ago.

With the managing-to-tree-height method, any tree tall enough to strike infrastructure is removed, and the zone along the infrastructure is managed thereafter to keep low-growing vegetation under and near the infrastructure — with ongoing integrated vegetation management (IVM) entries and techniques coupled with encroachment prevention.

To gain long-term risk reduction, encroachment prevention also must occur, including regular reentry to capture trees that have grown tall enough to strike facilities, perhaps as often as every 10 years to 15 years, depending on growth rates. This work should be done in conjunction with integrated management activities that minimize vegetation fuel near infrastructure.

To be clear: This method, coupled with managing the area around the infrastructure is a long-term commitment that must



Whiterock Cordova easements. Graphic by SMUD.

Segment of easement cleared to tree height, with logs ready for shipment to sawmill (El Dorado County, CA February, 2023).

be supported across the organization, so the benefits continue in perpetuity.

Real-World Example

The Sacramento Municipal Utility District (SMUD) has been a leader in using technology to identify trees that constitute a risk to its infrastructure. In one case, it used remote sensing and LiDAR along the rights-of-way to detect trees tall enough to strike infrastructure. SMUD also is in the process of thinning the area along the infrastructure to create a shaded fuel break.

It is noteworthy to point out this work was conducted on federal lands, and partners at the agencies took a leadership role with SMUD to conduct work that would meet both parties' objectives.

Engineering Benefits

Utility vegetation managers have long recognized the multiple benefits derived from vegetation management that support the engineering and equipment elements of fire mitigation plans. Concentrated, strategic vegetation management changes the fire environment and resultant engineering and equipment requirement — to the benefit of the utility and surrounding communities. With more outreach and education, utility engineers and maintenance managers may recognize the benefits and forge strong relationships with vegetation managers for mutual benefit.

However, this approach requires comprehensive, sophisticated planning and collaboration on all levels at a utility and that includes a vegetation management team that works closely with landowners, including federal and state owner agencies, regulatory agencies, interested parties, customers, fire prevention agencies, foresters and, ultimately, contractors that conduct the work. It is a complex, dynamic realm that requires sophisticated, nuanced, experienced professionals to navigate. It also requires senior leadership support for the long term.

Opportunities Throughout The West

Throughout the West, there are plenty of locations where managing vegetation near infrastructure to tree height can and should occur. The barriers to doing work like this are formidable but slowly coming down because proponents and opponents of vegetation management are aligned in their opposition to wildfire and understand the wildfire risk profile of the West must change.

One company with experience managing vegetation to tree height for Western utilities is JH Land Consultants. Its approach to vegetation management focuses on reducing both the ignition and carry components that make up wildfire risk while rendering landscape-level results in a cost-effective way. The company offers turnkey solutions, project by project, that provide utility rights-of-way with little or no risk of vegetation interactions with infrastructure and vegetation fuel loads/regimes that are likely to cool off a fire, slow it down and even stop it under the right conditions. In addition, it specializes in selling the timber produced during vegetation management activities to generate funds and offset costs.

With more utilities starting to embrace the practice of managing vegetation to tree height, it is time for vegetation managers to consider how this approach could help to lower risk of wildfires along their utility's T&D systems. TDW

NIEL FISCHER (*niel.fischer@gmail.com*) is a registered professional forester and attorney at law with 35 years of experience in private forest management, utility vegetation management, law and policy. From July 2019 to July 2022, Fischer managed operations on 191,000 acres (77,295 hectares) in California and Oregon and sourced two sawmills. From 1990 until 2005, he practiced nonindustrial forestry throughout northern California on ownerships ranging in size from 3 acres to over 35,000 acres (1.2 hectares to over 14,164 hectares). Fischer spent more than 13 years in between his forestry work at Pacific Gas & Electric Co., where he developed its hazardous tree rating system and authored its vegetation management rate cases. He also is a contributor to the ANSI A-300, Part Nine, Hazardous Tree Arboriculture Standard Best Practices companion publication.

ERIC BROWN (*Eric.Brown@smud.org*) is manager of the vegetation management department at Sacramento Municipal Utility District (SMUD). He is a Certified Arborist, TRAQ certified and a past president of the Utility Arborist Association. Brown has his bachelor's degree in forestry and range management from the University of Nevada, Reno. He is a director of the El Dorado Fire Safe Council and deeply connected to the people and resources of central California. Brown has over 25 years of experience in the utility vegetation management profession, mostly in northern California where he has witnessed firsthand how fire risk has changed.

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Utility workers install a new pole in a forested area of the PGE service territory. Photo by Portland General Electric.

PGE Deploys AI, Advanced Tech to Reduce Wildfire Risk

The Pacific Northwest utility is advancing its wildfire mitigation plan by hardening the grid and enhancing situational awareness with detection systems.

*By **DAN NUÑEZ**, Portland General Electric*

Wildfire risk reduction, wildfire mitigation and wildfire resilience are now common descriptors used to encapsulate the strategic investments, operational modifications and public partnerships utilities throughout the West are leveraging to keep communities safe. An ongoing process, this work is laying the foundation for long-term solutions that will enable utilities to deliver reliable and resilient power to customers through extreme weather events, including wildfires.

Portland General Electric (PGE) is in a multiyear phase of advancing its wildfire mitigation plan, from crunching data to better understand where the greatest and most impactful wildfire threats in its service area currently exist to executing on large capital system-hardening efforts to reduce the chance its equipment is the source of a potentially catastrophic wildfire event.

In 2019, PGE developed its first wildfire mitigation plan and, shortly thereafter, stood up a dedicated wildfire mitigation and

resiliency (WM&R) team. This team is the big-picture planning and boots on the ground that reflects the utility's commitment to wildfire risk reduction. While focused on numerous actions to tackle potential wildfire risks, the team also works closely with key partners across the region, including local and state emergency management and other electric service providers, to foster a coordinated effort to mitigate a risk that potentially impacts everyone.

"There is no one-size-fits-all response to wildfire," said Bill Messner, PGE's director of WM&R. "We have a deeper understanding of where the greatest risk is and we're delivering risk-reduction plans based on that analysis. But this work extends beyond wildfire season — ensuring system resiliency and making risk-management decisions is a year-round, multifaceted effort."

AI Camera Detection System

As of today, PGE is investing approximately US$110 million over five years in technologies, capital hardening of the electric system, data platforms and expertise to enhance its resiliency and situational awareness. These investments are an integral part of the utility's compliance with North American Electric Reliability Corporation standards and enable better geographic information system data quality, thereby improving operational efficiencies — whether that is managing vegetation, surveying, or design and engineering.

As an example, PGE's remote sensing program, a capital investment, uses light detection and ranging data, aerial imagery and hyperspectral imagery. The PGE team then uses analytics to inform predictive modeling for wildfire, asset management and geographic risk modeling. PGE also collaborates with fire and state agencies to make iterative improvements to the modeling. As a result, the technology helps PGE to make decisions that consider public safety, environmental and customer impacts, and costs in high-risk fire zones and public safety power shutoff areas.

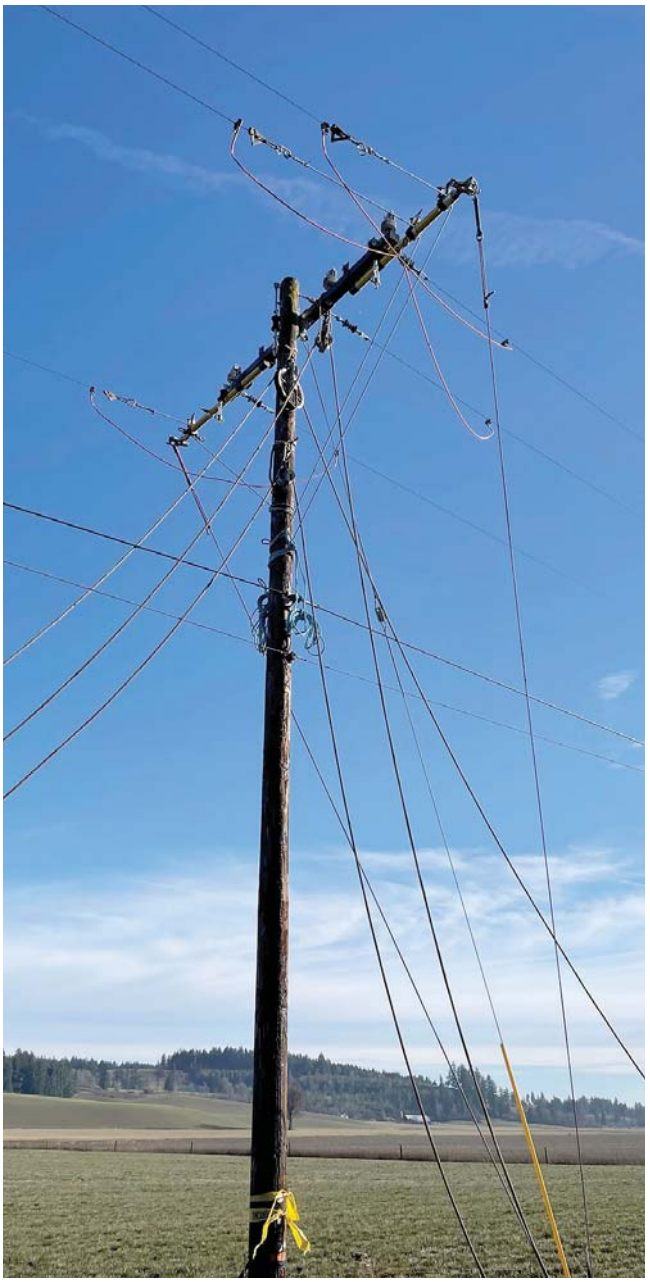
Wildfires are caused by a wide array of factors, and another of PGE's remote sensing investments is a cutting-edge Pano HD artificial intelligence camera detection system, which can detect ignitions and triangulate their location in real time. PGE has 26 Pano AI cameras that cover high-risk

New conductor ready to install in the Willamette Valley. Photo by Portland General Electric.

A utility worker clips in a new conductor to a distribution crossarm. Long-term system hardening projects — including overhead-to-underground conversion, covered wire and intelligent reclosers — are critical to the reduction of wildfire risk. Photo by Portland General Electric.

PGE is investing about US$110 million over five years in technologies, capital hardening of the electric system. Photo by Portland General Electric.

A power pole equipped with a new conductor, X-arm and cutouts. Photo by Portland General Electric.



PGE has deployed an early fault detection system, enabling operators to detect abnormalities in equipment or operations before a failure occurs. Photo by Portland General Electric.

fire zones, and the company shares this increased situational awareness with nearly 40 land management and fire agencies across Oregon.

Minutes matter when managing a fire. In the summer of 2022, PGE's array of AI cameras detected a fire south of Hagg Lake 140 minutes before traditional 911 and satellite detection methods. Fire crews with the Oregon Department of Forestry were able to drive directly to the incident, whereas in the past, it could take hours to identify the location of a fire.

"The Pano AI cameras enable PGE to keep up with the pace of climate change and wildfire risk while system hardening projects go from planning to execution," Messner noted. "We are contributing to wildfire risk reduction across the state of Oregon and are serving as a leader in game-changing wildfire management and situational awareness."

Early Fault Detection System

PGE has deployed an early fault detection (EFD) system, enabling operators to detect abnormalities in equipment or operations before a failure occurs. These cutting-edge risk management devices listen to the electrical noise coursing through power lines, which helps to reduce wildfire risk and improve reliability by minimizing outage time and, more importantly, allows for proactive intervention to correct faults before they occur.

PGE put this new system to use in the summer of 2022, when a power line sustained damage in a high-risk fire zone near Mount Hood, Oregon. Understanding what was going on and where enabled PGE crews to correct the issue before a downed-wire ignition event could take place. PGE is placing EFD sensors in high-risk fire zones, which will help to minimize outage time by reducing the time it takes to travel to the fault location, which, depending on conditions, can take hours.

PGE has 26 Pano AI cameras that cover high-risk fire zones.

Rooted in Safety

Even in historically wet, mild Oregon, summers are getting hotter and drier, resulting in longer fire seasons and an overall increased risk of wildfires. PGE is working harder than ever to reduce that risk while delivering reliable service.

Looking to the future, the company continues to enhance its situational awareness through advanced AI and tech, as well as using data analysis to improve on tried-and-true system hardening tactics for quicker and efficient project delivery. Whether these strategic investments live under the terms risk reduction, mitigation, or resilience the fact remains that this important work is rooted in a core company principle: Safety. TDW

DAN NUÑEZ is Wildfire Planning & Analytics manager at Portland General Electric. He is a certified project management professional and is certified with the Institute of Asset Management. He is also a developer and change manager for ISO-55000 & ISO-31000 business integration and practices for asset management and involved with the Oregon Hispanic Chamber of Commerce. He is a graduate of California Polytechnic State University at San Luis Obispo with a B.S. in structural engineering.

SDG&E sought approval from the Federal Aviation Administration to use drones for multiple use cases, including assessments. It was one of the first utilities to receive approval in 2014. Photo by SDG&E.

SDG&E Expands Drone Program to Detect Damage

The utility takes the use of drones for preventive assessments further by automatically detecting damaged assets from drone-captured images.

*By **TOM FRIES**, San Diego Gas & Electric Co.*

Following the devastating 2007 wildfires, San Diego Gas & Electric Co. launched its wildfire mitigation program, making significant investments in a wide range of technologies designed to help significantly reduce the chances of a utility-related wildfire. One such technology is the use of unmanned aerial systems, or drones.

Drones have proven highly valuable, enabling the utility to complete a wide variety of missions aimed at not only reducing the risk of wildfires but also increasing the safety of its employees while reducing costs. One of these missions, and perhaps the most critical, is the quick and efficient assessment of power lines and equipment within areas at risk of wildfire.

Preventive Assessments

Every year, San Diego Gas & Electric (SDG&E) uses drones to conduct thousands of routine preventive assessments on its infrastructure to identify and repair damage before an outage, but these assessments become particularly critical following extreme weather conditions, in which the utility may have had to proactively turn off power as a last resort to help protect homes and communities from utility-related wildfire risk. Infrastructure must be carefully inspected for damages prior to reenergizing the lines and restoring power as quickly and safely as possible.

Typically, utilities send field crews to visually inspect equipment for damage, which can require significant personnel hours,

increasing costs, the chance of worker injuries and the possibility of damaging the surrounding environment when driving or hiking through sensitive habitats. Utilities, including SDG&E, also have used helicopters, which also comes at a cost. Therefore, SDG&E sought approval from the Federal Aviation Administration to use drones for multiple use cases, including assessments. It was one of the first utilities to receive approval in 2014.

Since then, the company's use of drones has expanded and the utility developed its Drone Investigation, Assessment & Repair (DIAR) program. The DIAR program includes the deployment of numerous highly advanced drones to assess tens of thousands of poles, power lines and equipment and capture millions of images, which are then uploaded to a central database for review by qualified linemen. The advantages of drone inspections over ground inspections were quickly realized, including the top-down and close-up views drones provided. This helped the utility to identify additional issues to repair, leading to a more effective inspection program. However, SDG&E also realized drones could be used for more applications.

"I knew they were collecting the images, so the question was, 'Could we apply computer-vision models to help us be more efficient long term in our maintenance and fire prevention efforts?'" said Gabe Mika, strategic technology and investment manager for SDG&E. "Could we use the drone shots to build machine-learning models, and make this kind of drone program not just real, but something that had real benefits for our customers?"

Key Facts

Drone program start: 2014
Drone Investigation, Assessment & Repair program start: 2020
Number of drones: 26
Key use cases:

- Infrastructure assessments
- Vegetation assessments
- Post-wildfire assessments
- Line pulling
- Construction monitoring
- Accessing remote areas
- Pinpointing outages

Intelligent Image Processing

Analyzing millions of images is an arduous task and takes time. By using artificial intelligence, the digital acceleration team in the Information Technology department was brought in to see if the process could be streamlined further. Through intelligent image processing, SDG&E is now using artificial intelligence and machine learning to automatically detect damaged assets that could lead to an ignition.

"First, machine learning models were created to detect unique asset and damage conditions from the drone program imagery, including insulator, transformer, wooden pole and crossarm damage," Mika explained. "We involved qualified electrical workers to train the machine models to identify specific equipment damage by drawing a bounding box around an example of damaged equipment on an image. Then, that image is used to teach the machine software to automatically identify the same pattern of damaged equipment in future images."

After teaching the image-recognition models to accurately identify the equipment by tagging and confirming the contents of all 2.3 million photos, SDG&E's team applied their experience

The advantages of drone inspections over ground inspections were quickly realized, including the top-down and close-up views drones provided. Photo by SDG&E.

A feedback loop was created within the platform, enabling qualified workers to validate machine learning results to optimize the model performance. The team built a map-based user interface to visualize and browse for imagery and machine learning results stored in the image repository. This helped the utility to identify additional issues to repair, leading to a more effective inspection program. Photos by SDG&E.

to grading the condition of equipment. By adding the insights of experienced linemen upfront, the data and model became far more accurate when analyzing images. And if the technology is unable to analyze the images, the model sends them to qualified technicians for further review.

This technology enables the utility to quickly identify damage that could lead to ignition and helps it to prioritize and initiate work in the field to repair the equipment.

The team built a map-based user interface to visualize and browse for imagery and machine learning results stored in the image repository. To facilitate continuous improvement and refinement of the models, a feedback loop was created within the platform, enabling qualified workers to validate machine learning results to optimize the model performance.

AI & Machine Learning Models

Since officially kicking off in April 2020, the project team has built more than 35 artificial intelligence and machine learning models. Each one of these models is designed to automatically identify an SDG&E asset and identify a specific type of damage or specific type of condition.

The multi-departmental team, together with the asset management and operations departments, has changed the utility's approach to managing the immense electric infrastructure portfolio. Intelligent image processing is truly groundbreaking and promises to be a game-changer in SDG&E's mission to mitigate wildfire risk, minimize outages for customers and ensure the safety of the communities it serves.

The DIAR program is just one of many wildfire mitigation projects included in SDG&E's wildfire mitigation plan filed annually with the California Public Utilities Commission. The plan outlines ongoing practices and additional improvements SDG&E will make to mitigate wildfire threats. TDW

Editor's note: For more information on SDG&E's 2022 plan, visit *sdge.com/2022-wildfire-mitigation-plan*.

TOM FRIES has been with SDG&E Aviation Services for over 5 years. Prior to coming to SDG&E, Tom worked for General Atomics Aeronautical with program and engineering teams. Tom is a retired Marine with 22 years of active duty as an F/A-18 pilot. Tom has his undergraduate degree in Mechanical Engineering Technology from Temple University, master's degrees from both Georgetown University and University of San Diego, and Aviation Safety and Security certificate from University of Southern California.

Wildfire sweeps the mountainside, crossing metal transmission towers. Photo by iStock/Getty Images Plus.

How To Select Pole Material With Wildfires In Mind

Xcel Energy, SDG&E and the Snohomish County PUD share insights on fire hardening and their wildfire protection plans.

*By **BRAD HENNESSEY** and **MEGAN HAPPEL**, POWER Engineers Inc*

Intense wildfires often damage the T&D systems that fall within their paths, making it a challenge for utilities to stay operational in high-risk areas during times of crisis. In some instances, utility poles can even contribute to the ignition and spread of a fire. With no industry agreement on which materials are best in fire-prone areas, it can be difficult to decide which ones to use for wildfire mitigation. However, it is vital utilities thoroughly consider their options now, so they can protect their assets and communities during future catastrophes.

In general, utility poles are made of four primary materials: wood, metal, fiberglass and concrete. Unfortunately, there is no one-size-fits-all solution, and the best option depends largely on a utility's location, design criteria and state of existing systems. To get a better understanding of where these materials work best, Xcel Energy Inc., Snohomish County Public Utility District (PUD) and San Diego Gas & Electric Co. (SDG&E) share insights on fire hardening and their wildfire protection plans.

Xcel Energy

Xcel Energy services many U.S. states, but generally only experiences wildfires in Colorado, said David Flaten, senior distribution engineer at Xcel. In 2021, the utility estimated around 3000 line miles (4828 line km), or 70,000 individual poles, were vulnerable because of their location in wildfire zones. Because of the extra costs of switching to new poles, Xcel continues to use wooden poles, usually southern pine or cedar, in these areas. By covering the wood in fireproof wraps and fire-resistant coatings instead of replacing them, Xcel can harden line miles faster and with lower cost.

Metal transmission tower overlooks a fire scarred mountain. Photo by POWER Engineers.

They also have used laminated wood poles, often in their more mountainous locations. According to Flaten, "As long as it's not priorly damaged, [a laminated pole] is probably going to survive at least as well as a solid wood pole, if not better."

Damaged wooden poles are more vulnerable to fire than solid ones, and lamination provides them with an extra barrier of protection. Xcel's network of wooden utility poles is extensive, and because of this, they are doing all they can to harden their existing wooden structures against fire.

Snohomish PUD

Snohomish PUD, on the other hand, prefers all metal structures, said Gordon Hayslip, the utility's senior manager of transmission engineering and standards. Located in Washington state, wildfires are not typically on the radar for this public utility. However, because of climate change, recent fires have been creeping closer and the utility wants to proactively solidify its wildfire plan before fires become a big problem.

Snohomish started phasing out wooden poles long before it was concerned about fire. Though it was woodpecker damage that inspired the initial transition to metal, the same properties that protect against critters and heart rot also can provide benefits in wildfire hardening.

"It is expensive to replace a transmission pole, but it's such a critical asset the incremental cost of going to a non-wood pole is really minor," Hayslip said.

As Snohomish learned, if poles are regularly subjected to damaging forces, whether that be the beak of a woodpecker or the bite of a flame, then it makes a lot of sense to invest in something sturdier so they don't have to be replaced as often.

The utility tried several non-wood options before arriving at ductile iron. For a while, it used spun concrete poles, courtesy of a local manufacturer. However, because of the weight of the material, this option often is not feasible unless provided by a local supplier. Since transportation and installation of the heavy material is more complicated, Snohomish PUD discontinued this practice in favor of lighter metal structures.

"It has been our experience in wood pole class equivalents that ductile iron is much more cost competitive than classic steel," Hayslip said. "In some cases, we found that the price of ductile iron is almost the same as wood when you're getting into 75- to 80-ft [23- to 24-m] H4 or better pole sizes. There's really almost no cost adder to go with ductile iron."

Overhead view of metal transmission tower surrounded by scorched earth. Photo by POWER Engineers.

Since going with metal poles, Snohomish PUD also has noticed a variety of side benefits of the material. In the event of a phase contact with the arm, because of something like an insulator break or a loose tie, a conductive pole will trigger upstream protection devices much more quickly than a wooden pole, which may burn and allow wires to fall to the ground. With metal, the utility also does not have to worry about grounds being stolen by copper thieves since the pole itself is the ground.

Snohomish PUD hopes that by integrating metal poles into its system, it can create a pole line with a life span of 70 years to 80 years.

SDG&E

SDG&E also prefers metal structures, said Christian Henderson, electric distribution engineering manager at SDG&E. In

2021, the utility estimated it had around 54,000 circuit miles (86,905 circuit km), or 80,000 distribution poles, in what it refers to as high fire threat districts. After enduring some devastating fire damage in 2007 and 2008, wildfire mitigation has become one of its top priorities.

"We transformed from wood to steel," Henderson noted. "We have a requirement now in our high fire threat districts for either steel or fiberglass."

Steel structures usually are SDG&E's first choice, but the conditions do not always allow for it. In known corrosion areas or challenging environments such as wetlands, the utility will often use fiberglass instead. However, fiberglass poles come with their own set of challenges. For instance, fiberglass is not very rigid and can have some issues regarding deflection.

Utility poles and wind turbines in the path of an approaching wildfire. Photo by POWER Engineers.

To avoid unforeseen damage, SDG&E often sizes fiberglass poles slightly larger than normal, and the utility is always mindful of the type of loading and stress the poles will have to endure. It has even built multiple weather stations to assess the wind strain on its poles and account for actual conditions during design, so it can engineer systems that are less likely to fail.

According to Henderson, fiberglass poles also are challenging because "the tools you need to work with a fiberglass pole are considerably different than the tools you need to work with a ductile iron or a steel pole." This means that crews who are new to fiberglass will need to be retrained and familiarized with the new equipment, which takes time.

Wooden poles in the face of fire. Photo by POWER Engineers.

Be Proactive

Wildfires are a recurring threat for utilities in at-risk regions. Being proactive about wildfire mitigation now can end up saving utilities money in the long run. It is time for all electric utilities to start thinking about their wildfire plan and which pole materials will work best for them. TDW

Editor's note: For more information on what to consider during pole material selection, such as how to involve stakeholders, watch POWER's webinar on "Pole Material Selection for Fire-Prone Systems."

BRAD HENNESSEY (*brad.henessy@powereng.com*) is a senior project engineer and business unit director at POWER Engineers. He specializes in underground and overhead T&D systems and currently oversees POWER's 400+ professionals dedicated to distribution engineering and design across North America. He holds a bachelor's degree in electrical engineering from Montana State University and a master's degree in engineering management from the University of Colorado. He is also a licensed electrical engineer in Arizona, California, Idaho, Washington, Oregon and Texas.

MEGAN HAPPEL (*megan.happel@powereng.com*) is a content developer, writer and editor for POWER Engineers. She specializes in transforming complex engineering projects into concise, relevant content for a wide variety of audiences and channels. She holds both a bachelor's degree in engineering management and a bachelor's degree in scientific and technical communication from Michigan Technological University.

Old Practices Are New Again: TEK and Cultural Burning

Fire is being used as a vegetation management tool to promote ecological diversity and reduce the risk of catastrophic wildfires.

*By **M.K. YOUNGBLOOD**, ACRT Pacific*

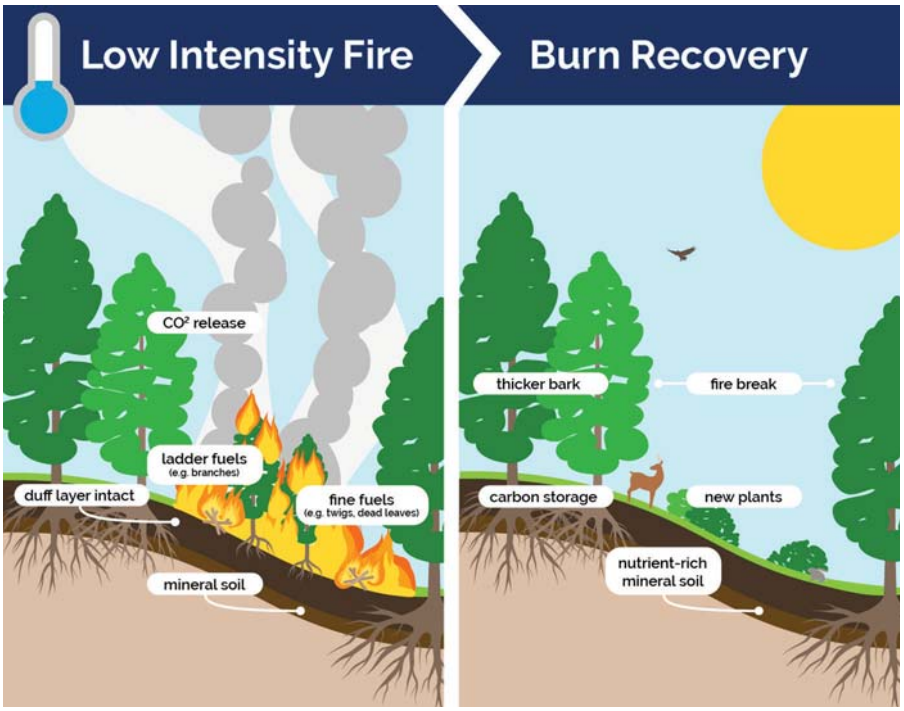
Wildland fires are happening across the United States. According to a June 2022 *T&D World article* by ACRT Services Senior Manager Bob Urban highlighting the sheer amount of damage these fires can produce, 2021 saw nearly 59,000 wildfires burn more than 7.1 million acres (2.8 million hectares), and 2020 saw the highest number of acres burned — 10.1 million (4.1 million hectares) — over the preceding five-year period.

With the volume of land impacted by wildland fires, it is natural to look for environmentally friendly solutions. This is where a basic understanding of traditional ecological knowledge (TEK) and cultural burning can become an asset.

Vegetation Management Practices

Vegetation management practices are always evolving. Early in America, indigenous communities managed their ancestral

(Top) Ron Goode, North Fork tribal elder and cultural burning practitioner. Photo by Pacific Southwest Research Station. (Bottom) In early America, fire was a tool that promoted ecological diversity and reduced the risk of catastrophic wildfires. Photo by ACRT.



lands in a variety of ways. For thousands of years prior to colonization, fire was integral to many Indigenous people's way of life. Indigenous people on what is now called Turtle Island in North America used fire to travel, manage the land for cultivation of fauna (animal life) and flora (plant life), hunt game and more. Fire was a tool that promoted ecological diversity and reduced the risk of catastrophic wildfires.

With wildfire season seemingly year-round now, particularly on the West Coast, it appears new, or rather old, techniques need to be used to combat this. Some new terms are being used in vegetation management regarding the practice of fire as a vegetation management tool: "TEK" and "cultural burning," and periodically they go together.

TEK is defined by the National Park Service as the ongoing accumulation of knowledge, practice and belief about relationships between living beings in a specific ecosystem that is acquired by Indigenous people over hundreds or thousands of years through direct contact with the environment, handed down through generations and used for life-sustaining ways. This knowledge includes the relationships between people, plants, animals, natural phenomena, landscapes and the timing of events for activities such as hunting, fishing, trapping, agriculture and forestry.

TEK encompasses the worldview of a people, including ecology, spirituality, human and animal relationships, and more. In stark contrast to Western society science, TEK uses more holistic and inclusive beliefs.

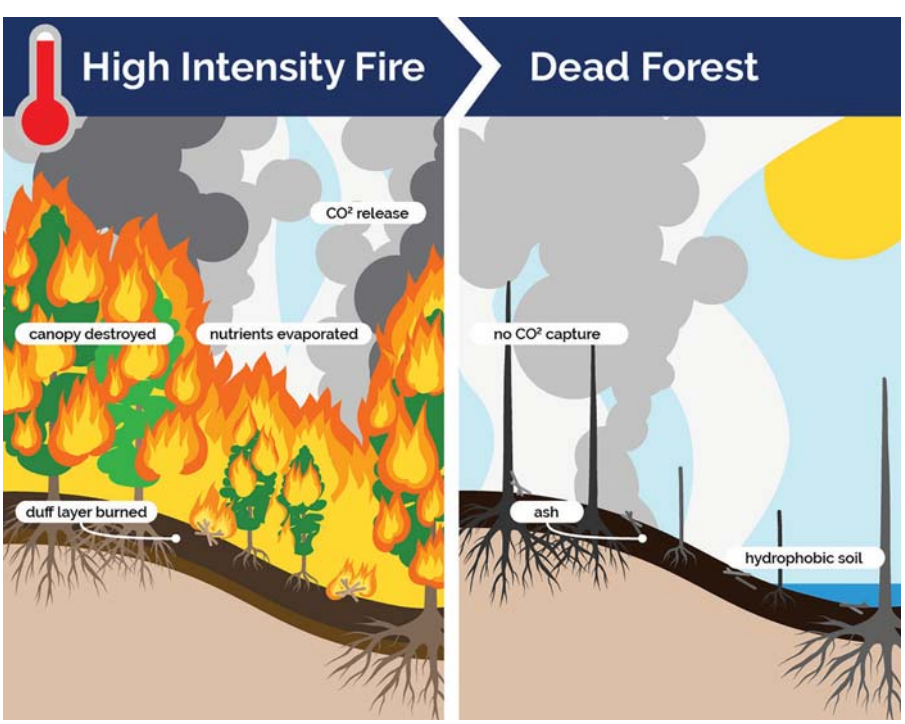
Cultural Burning

Many indigenous communities and tribes use traditional cultural burning practices with TEK to cultivate their lands. This practice typically uses a small, controlled fire to provide a needed result monitored by a tribal burn boss or traditional practitioner of fire. The U.S. Forest Service has seen the value of these traditional fires and adopted some of the uses in clearing ladder fuels from heavily forested areas at risk of a catastrophic fire, and many other entities are taking notice.

"Cultural burning links back to the tribal philosophy of fire as medicine," said Frank Kanawha Lake, a research ecologist with the U.S. Forest Service and wildland firefighter of Karuk, a tribe in Northern California. "When you prescribe it, you're getting the right dose to maintain the abundance of productivity of all ecosystem services to support the ecology in your culture." Most cultural burns use low-intensity fire to aid in burn recovery. This creates a manageable fire, which enables better burn recovery.

Fire Intensities

Low-intensity fire cultural burning is best in these: cool, moist and low wind speeds. However, depending on the specific vegetation to be targeted for cultivation, it may occur in various months. One of the most critical aspects is the fuel load, which



Many Indigenous communities and tribes use traditional cultural burning practices with TEK to cultivate their lands. Photo by ACRT.

needs to be low. The fire should be lit on a high incline to force the fire to work slowly downhill, preventing it from fuel loading uphill and blowing up into a monstrous, uncontrollable fire — like the Hermits Peak Fire in New Mexico, set by the U.S. Forest Service, that escaped containment and caused millions of dollars in damages.

High-intensity fires differ because of the damage the fire does, wiping out the duff and creating hydrophobic soil that can create erosion issues, mudslides and flash flooding issues. Indigenous peoples knew this and, thus, managed their lands with TEK, passing down the traditional knowledge from many generations to today.

Currently, in the Central Valley of California, there is a resurgence in TEK usage and cultural burning, thanks to North Fork Mono Tribal Elder Ron Goode, who has decades of cultural burning experience, and the next generation of tribal burn bosses like Ray Gutierrez, a Wuksachi tribal member, who has advanced degrees in forest ecology. Gutierrez is merging his traditional knowledge with academia to help cultivate gathering materials, such as redbud and sourberry. According to Mono elders, sourberry sticks used for basket making need to be cultivated with fire; otherwise, the plant grows up bushy and the shoots grow crooked, unsuitable for basketry. Mono Elder Julie Dick Tex explained that "a gentle fire clears the brush, regenerates the plant, and coaxes new shoots straight toward the sun."

Wildfire Education

Students in Humboldt County, California, are being introduced to Native American science, technology, engineering, art and math (STEAM) and studying TEK. As part of that, they are learning about cultural burning. A press release in the *North Coast Journal* shared the curriculum for elementary and middle school-aged students, which included teaching how "fighting fire with fire helps prevent wildfires."

Oregon State University's college of forestry is studying TEK and is home to a traditional ecological knowledge lab. Currently, the students are conducting two studies: A three-year Pacific Northwest ethnobotany, seed collection and tribal conservation corps ecocultural restoration pilot project, and a five-year project to expand on an interdisciplinary ethnobotany and TEK pilot project initiated by Dr. Cristina Eisenberg in 2019.

Wildfire Education

As Bob Urban noted in his fire safety *T&D World* article, "Everyone is stewards of the land they manage and work on, and a living fire plan is one of the best ways to ensure it continues to thrive for years to come."

When drafting vegetation management and wildland fire safety plans, it is beneficial to keep TEK top of mind. One might ask: What does TEK truly mean for vegetation management? A well-balanced approach to the future of the electric utility industry is the answer. By using indigenous best practices and Western science — acculturating the best of both — the industry will become more resilient and foster mutual respect for tribal and non-tribal knowledge. In a University of California, Davis article by Kat Kerlin, "Rethinking Wildfire," cultural burning and TEK can be summed up with one quote by Mono Elder Ron Goode, "There's a difference between cultural burning and just setting fire on the land. We use fire as a tool."

M.K. YOUNGBLOOD serves as the safety manager and tribal liaison at ACRT Pacific. He has more than 30 years of public service and first-responder experience with core proficiency in American Indian law, American Indian culture and disaster cleanup. Youngblood also serves as a certified instructor for the U.S. DOE (National Nuclear Security Administration and Center for Radiological Nuclear Training), U.S. Emergency Management Institute and Center for Domestic Preparedness. He has earned his California Naturalist designation from the University of California, Davis and serves as the tribal historic preservation officer for the Haslett Basin Holkama Mono Nation in Fresno, California.

It is not uncommon for utilities to face billions of dollars in wildfire costs, including damage to infrastructure and resources needed for restoration. Photo by panaramka-iStock/Getty Images Plus.

Real-World Wildfire Mitigation From Space

Rural electric cooperative replaces inefficient, manual systems with intelligent vegetation management system to manage wildfire threats.

*By **ABHISHEK VINOD SINGH**, AiDash*

Wildfire season now seems to last all year, without much of an off-season for recovery. Wildfires around the world can be summed up in two words: "escalating" and "devastating." Advancing climate change, with its storms and droughts, supports rapid forest growth, which leads to dry and starving trees and builds an abundant source of flammable kindling.

The impact of wildfires is heartbreaking:

- Lives lost — In the last two decades, wildfires have been responsible for thousands of lives lost around the world.
- Acres burned — In 2021, wildfires burned 7 million acres (2.8 million hectares) of land in the U.S., according to the National Centers for Environmental Information.
- Fiscal impact — It is not uncommon for utilities to face billions of dollars in wildfire costs, including damage to infrastructure and resources needed for restoration.
- Liability — In many cases, insurance is either incomplete or simply unavailable. Even with insurance, utilities can still be held liable for massive amounts of money and even criminal charges.

Regulators now require utilities to have wildfire mitigation plans in place, and many utilities are opting for rolling blackouts or public safety power shutoffs, which come with their own host of reliability and customer satisfaction problems.

Pity the utility vegetation manager who must keep any flame from reaching any point along miles of T&D lines. Nature is not the sole cause of the rising wildfire risk. The expanding wildland-urban interface (WUI) exacerbates the natural dangers. Researchers at the University of Colorado Boulder estimate that 54% of Americans now live within 3 miles (4.8 km) of a forest, making them extremely vulnerable. The National Association of State Foresters also estimates that 63,661 communities are at risk of wildland fire and its dangers to life and property.

Electricity infrastructure is becoming more and more crucial as society demands the clean energy potential of electricity for vehicles, homes and factories. At the same time, utility regulators are requiring more scrutiny of utilities' vegetation management practices while the utilities themselves struggle with workforce shortages, a brain drain of experienced retirees and rising labor costs.

Intelligent Vegetation Management

As a rural electric cooperative in Colorado's mountainous northern front range, United Power, Inc. must be strategic with its

In the last two decades, wildfires have been responsible for thousands of lives lost around the world. Photo by ©gettyimages via Canva.com.

budgets and resources. Its Mountain District covers approximately 400 sq miles (1036 sq km), all of which are in a high-risk wildfire zone. Rugged terrain, high winds, winter storms and densely forested areas increase the coop's fire danger. With a relatively small investment in technology, it has yielded large returns in system resilience and reliability while conserving budget, staff, and resources. Moreover, the technology has helped the utility to manage wildfire threats.

United Power implemented AiDash's Intelligent Vegetation Management System (IVMS) to replace inefficient, manual systems that relied on office software and driving the 400 sq miles of overhead line.

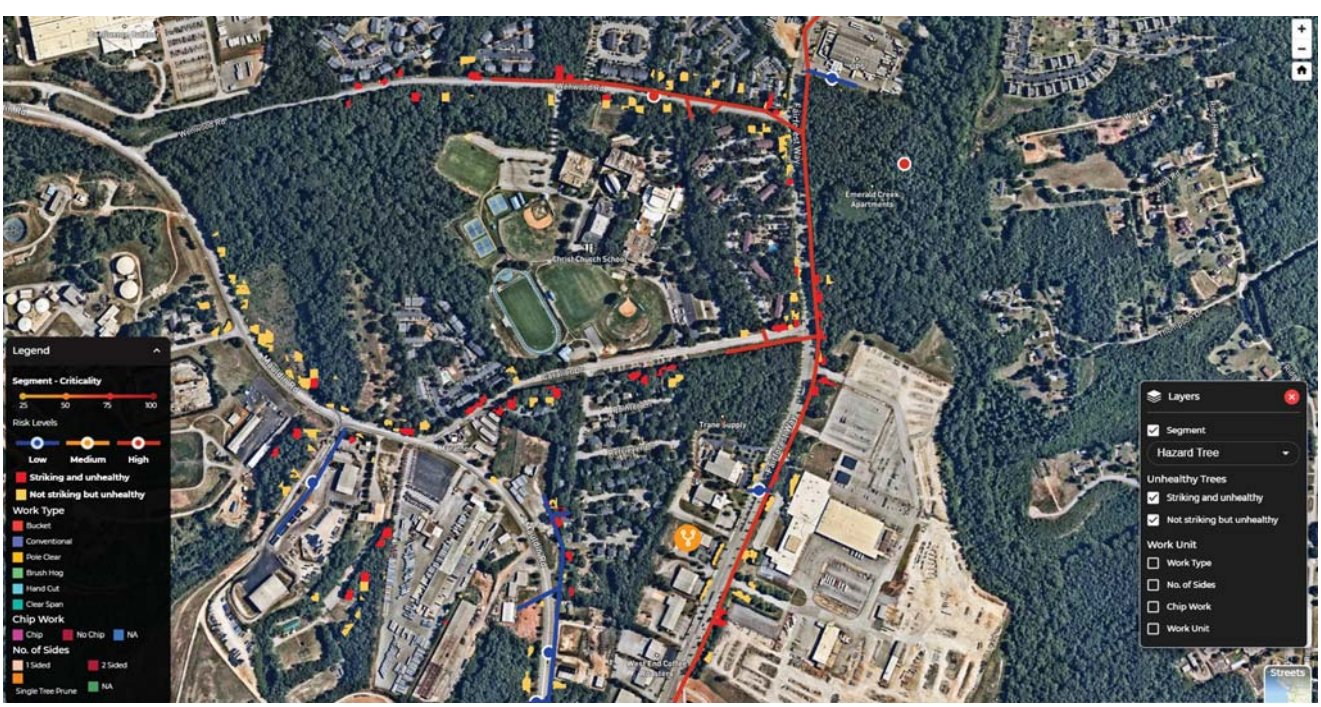
"I'm able to use our budget and strategically remove vegetation where we have the greatest risk of a wildfire and track cycle trims," said Holly Woodings, mountain area manager at United Power. "With satellites and AI, we can remove a hazard tree before it causes a power outage. All it takes is one dry, windy day and one tree to create a natural disaster."

How Innovation Fights Wildfires

Technology innovation is a juggernaut in this world and above it, as well. Specifically, satellite technology has come a long way since 1957's Sputnik. About 1000 new satellites now go up each year, offering seamless accessibility to Earth images. They can assess as many as 10,000 line miles (16,093 line km) per day, and imaging advancements now offer multispectral and even hyperspectral imaging along with synthetic aperture radar (SAR) that detects far more than the human eye. Image resolution has advanced from 88 yards to 12 inches (30 cm), with 4-inch (10-cm) resolutions almost ready for orbit.

With substantial improvements in computing, artificial intelligence and machine learning, these high-resolution images yield astonishing data about the state of wildland vegetation. The red-edge band of the spectrum detects hazard trees with declining health, based on dryness of vegetation. It also measures the chlorophyll and moisture content of all vegetation, identifies species and gauges soil conditions.

The AI also supports effective decision-making by identifying, predicting and monitoring hazard trees and other wildfire threats to T&D grids as well as supporting effective disaster response. It

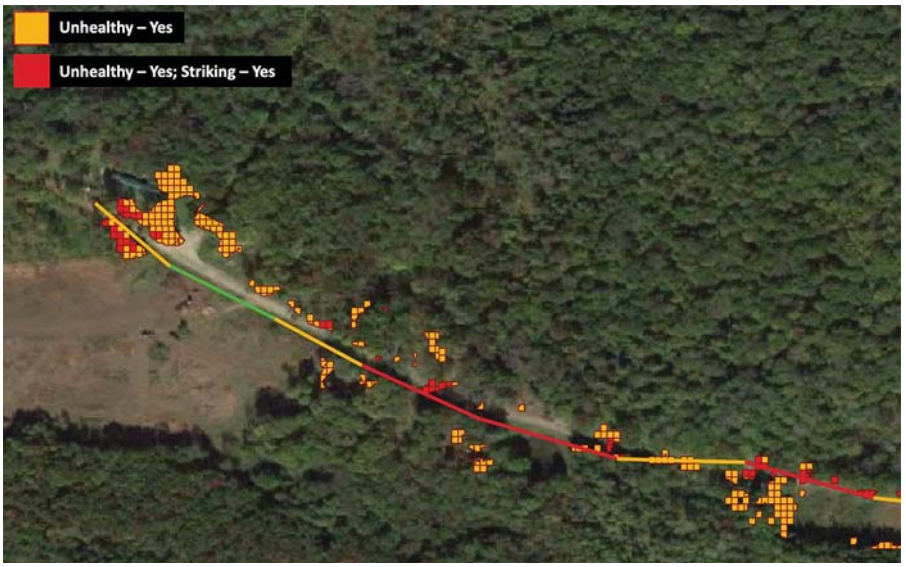


By taking on the data collection and analysis, these AI systems free up their human managers to focus on matters of evaluation and priority. The enhanced situational awareness helps vegetation managers to plan quickly, restore safely and communicate efficiently. Photo by AiDash IVMS product. Base map layer ©Mapbox, ©OpenStreetMap.

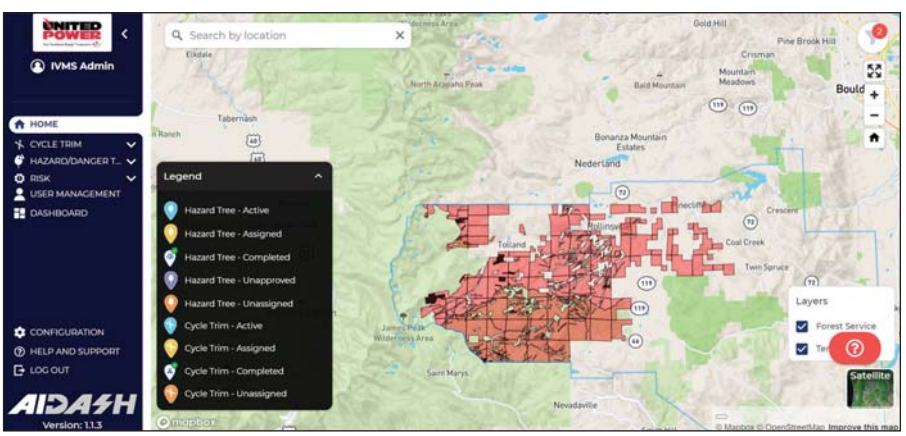
does this by integrating image data with other remote sensing data — such as light detection and ranging (LiDAR) information, ground truth from field inspectors and historical records of outages and causes — into a single workflow.

By taking on the data collection and analysis, these AI systems free up their human managers to focus on matters of evaluation and priority. The enhanced situational awareness helps vegetation managers to plan quickly, restore safely and communicate efficiently.

These advanced AI systems also help to build climate and wildfire resilience. A better view of a utility's network enables them to make more informed decisions to lower risk. Better data helps them to view several options to reach success. If one tree can cause a US$1 billion fire, then what if utilities could identify each tree with that potential anywhere on their network? Driving lines or sending up airplanes just cannot do it with enough speed or accuracy. It is impossible. However, advancements in technology already achieve this — economically.



When disaster strikes, utilities must know at the earliest possible moment. This may be with increased inspections, automated remote sensing and situational action plans. Utilities also need current, accurate data about weather patterns to set up an emergency response. Photo from AiDash IVMS Product. Base satellite image @CNES (2022), Distribution Airbus DS.



With the right mix of processes, technology, people and data, utilities can reduce wildfire risk drastically and offer safe, reliable power to the communities they serve. Photo by AiDash IVMS product. Base map layer ©Mapbox, ©OpenStreetMap.

Data Drives Wildfire Planning

With the abundance of data and insights now available through modern satellites and AI, they must be incorporated into each of the three phases of wildfire risk mitigation:

- **Prevention —** The adage "prevention is the best medicine" is twice as true with wildfires. It may be impossible to stop a natural disaster, but most wildfires are caused by people, and one of the leading drivers is utility related. For prevention, utilities need to apply all their data to gauge the key ignition causes: vegetation connecting with a power line and failed equipment. This means constant reevaluation of the vegetation management strategy to understand where to harden.
- **Detection —** When disaster strikes, utilities must know at the earliest possible moment. This may be with increased inspections, automated remote sensing and situational action plans. Utilities also need current, accurate data about weather patterns and insights on potential spread to set up an emergency response.
- **Response —** Boots on the ground get the power back on for the community as fast as possible. The data guides those boots to the highest priority locations with real-time visualization of the damage. Intelligent vegetation management systems also can alert crews to terrain anomalies and even recommend the necessary equipment. Every second counts in this phase. Homes, businesses, hospitals, prisons, schools and other critical assets should not be without power longer than is absolutely necessary.

Get Ahead Of Wildfire Risk

There is no question that wildfire mitigation is a top priority for utilities around the world. It is getting significant funding and is held under a microscope by the public. With the right mix of processes, technology, people and data, utilities can reduce wildfire risk drastically and offer safe, reliable power to the communities they serve.

United Power's Holly Woodings sums up the advantage she sees in applying advanced satellite and AI technology to prevent wildfires: "Being proactive is extremely important when you're mitigating risk." TDW

ABHISHEK VINOD SINGH (*abhishek@aidash.com*) is CEO and cofounder of AiDash. An alumnus of I.I.T. Kanpur, Singh worked with many IT companies prior to starting and growing a series of successful tech businesses including DbyDx Software & Edureka. He is based in Santa Clara, California.

Conducting regular inspections is an effective way for vegetation managers to prioritize treatment sites from one year to the next. Photo by Corteva.

Four Essentials To Wildfire Mitigation Programs

Investing time and resources in these four practices can significantly impact wildfire mitigation programs for electric utilities across the country.

*By **JEROME OTTO**, Corteva Agriscience*

Everyone has seen the devastation wildfires can cause. Buildings and homes often are decimated; evacuation routes are flooded with families in cars; and countless acres of land are ravaged in a matter of hours or days. Avoiding these unfortunate results can be challenging, but utility vegetation management programs can play an integral role in minimizing their occurrences and severity.

According to the California Department of Forestry and Fire Prevention, one in every 10 wildfires are caused by electricity. Statistically speaking, that means electric power was responsible for nearly 7000 of the 68,988 wildfires reported by the Congressional Research Service in 2022.

From dry conditions and high temperatures to rough terrain and varying densities of incompatible plant species, vegetation managers face numerous challenges as they work to prevent trees and other woody plants from causing wildfires and lapses in electrical service. Fortunately, utility vegetation managers can use the following strategies to prevent trees and other incompatible plant species from impacting utility infrastructure, which significantly enhances electrical transmission reliability and wildfire mitigation efforts as well as a utility's public image.

1. Conduct Regular Inspections

Optimizing resource management is essential for vegetation management programs, as resources often are expected to do more with less. By regularly inspecting managed land for areas where problematic trees and other incompatible plants pose the greatest threat to utility infrastructure, vegetation managers can

effectively prioritize the control and removal of vegetation that either poses a wildfire risk or threat to electrical transmission reliability.

In addition to inspecting vegetation throughout and adjacent to utility right-of-way (ROW) corridors, the following inspections can help to prevent utility pole failures and wildfire ignitions caused by inadvertent sparks:

- Check guy wire poles for wood decay or deterioration.
- Ensure security of guy wires and anchoring systems.
- Confirm bare-ground results around the base of each pole.

From dry conditions and high temperatures to rough terrain and varying densities of incompatible plant species, vegetation managers face numerous challenges as they work to prevent trees and other woody plants from causing wildfires and lapses in electrical service. Photo by Corteva.

2. Effectively Control Incompatible Vegetation

Environmental research studies have shown the exclusive use of mechanical control methods, such as mechanized mowing, generally is ineffective at providing long-term control of incompatible trees and other problematic plant species throughout the wire zone and border zone of utility ROW.

Mechanical control strategies can be used to remove undesirable vegetation. However, incompatible trees and a variety of highly flammable plant species will continue to spread and resprout as long as their roots remain intact, which only creates additional maintenance requirements over time. Vegetation managers are encouraged to use the following herbicide applications to complement mowing practices and effectively control targeted vegetation:

- Basal bark, basal cut-stump or dormant-stem treatments
- Grass-friendly brush mixes

Basal cut-stump treatments and other herbicide applications can be used to enhance mechanical control methods for long-term control of incompatible trees and other woody plants. Photo by Corteva.

- Hack-and-squirt treatments
- Cut-stubble treatments.

These impactful strategies can be used to support the development of desirable grasses and forbs that impede the development of incompatible trees and flammable non-native plant communities. Doing so ensures vegetation management programs successfully meet the power line clearance requirements established by their state while limiting potential fuel sources for wildfires. Moreover, supporting the release of beneficial grasses and forbs can help vegetation managers to establish fuel breaks throughout utility ROW, which provide safer environments for firefighters to combat the flames.

3. Remove Remaining Debris

Mechanical control methods can provide short-term relief to safeguard the integrity of utility infrastructure, and herbicide treatments can help to prevent the reestablishment of incompatible vegetation in the future. However, any debris that remains after these treatments can still provide ample fuel for a wildfire. Utility foresters and vegetation managers can use the following strategies to ensure these fire hazards are effectively removed or repurposed:

- Bale woody biomass for proper off-site disposal.
- Cut trees into lengths that can be sold to local mills.
- Use chippers to break down debris and broadcast to sloped areas for erosion control.

4. Prioritize Communication

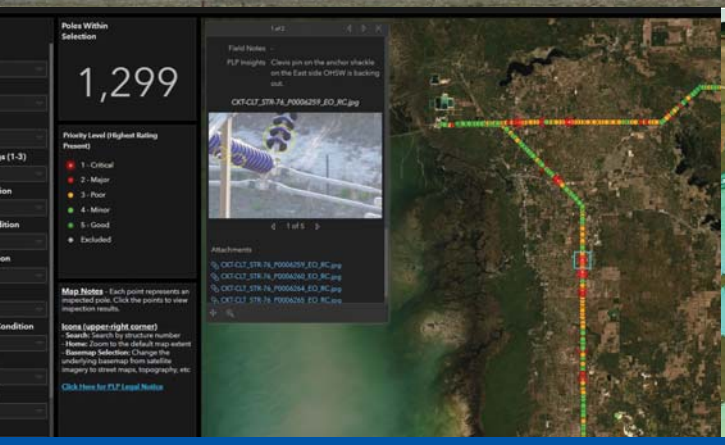
Public and private land often runs adjacent to utility ROW, making the use of effective vegetation control strategies on those sites equally important. While utility vegetation managers can collaborate with a variety of public and private entities to improve fuel load reduction and tree removal strategies in these areas, ensuring landowners and other land entities approve of each applied strategy is essential.

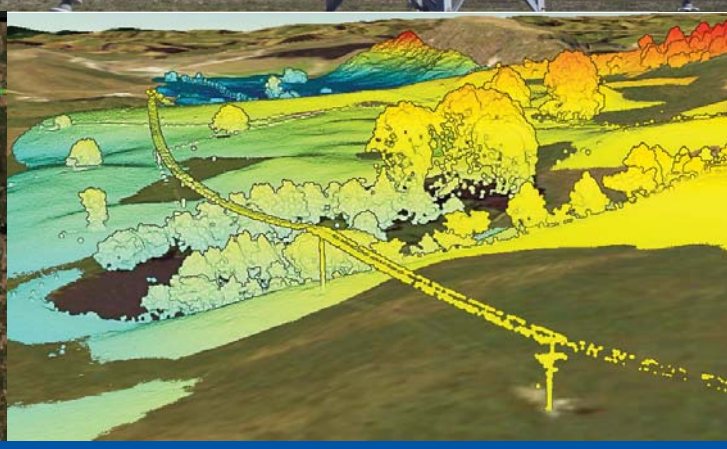
That is why Corteva Agriscience developed Notify Your Neighbor, a resource guide that contains valuable tools to help vegetation managers prepare for effective conversations with concerned members of the public. In addition to strategies, techniques and key messages that can help to increase compliance, reduce complaints and improve productivity, the resource also contains instructional videos and informative brochures that vegetation managers can engage with to refine public communications on their own time. To request access to Notify Your Neighbor, contact your local Corteva vegetation management specialist.

Vegetation managers often are the unsung heroes for utilities, and their impact reaches far beyond the edges of utility ROW. Their work not only enhances electrical transmission reliability and wildfire mitigation efforts but also a utility's public image. Effective vegetation control strategies can be used to ensure these positive outcomes; it is simply a matter of applying them in the right place at the right time. To learn more about best practices for managing incompatible vegetation throughout utility ROW and adjacent lands, visit *Utility.VegetationMgmt.com.* TDW

Supporting the release of beneficial grasses and forbs can help vegetation managers to establish fuel breaks throughout utility ROW, which provide safer environments for firefighters to combat the flames. Photo by Corteva.

JEROME OTTO (*Jerome.Otto@Corteva.com*) is a market development specialist with Corteva Agriscience. Otto uses more than 36 years of experience with agricultural solutions to support vegetation management specialists while serving as the interface between commercial sales and R&D for Corteva. He is based in Scottsbluff, Nebraska.





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