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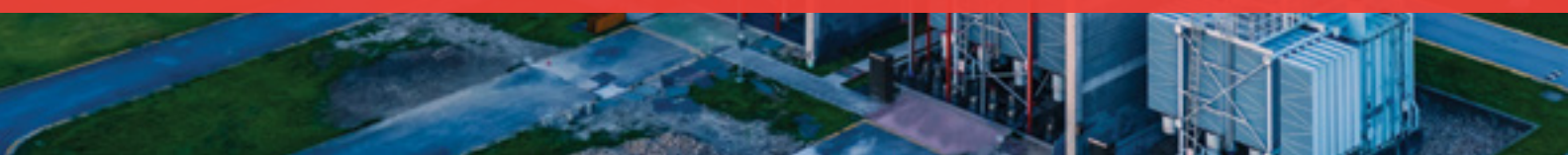
IMPLEMENTATION OF AN AUTOMATED MONITORING SYSTEM IN EXTRA HIGH VOLTAGE (EHV) SUBSTATION

FOR EARLY DETECTION OF FAILURE MODES USING ANALYTICS



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PUBLISHER
Steven Desrochers
steven@electricenergyonline.com

EDITOR IN CHIEF
Elisabeth Monaghan
elisabeth@electricenergyonline.com

ART DESIGNER
Z communications
r.poitras@zcommunications.ca

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Tel.: 888 332.3749 | info@electricenergyonline.com
electricenergyonline.com

AEP AFFILIATES SELECTED TO COMPLETE APPROXIMATELY $1.7 BILLION OF TRANSMISSION INVESTMENTS IN PJM REGION

February, 2025

Highlights

- Transmission system upgrades approved by PJM Board
- Investments will improve reliability and deliver more power to meet growing demand

American Electric Power (Nasdaq: AEP), and its competitive transmission affiliate Transource Energy, LLC[1] (Transource Energy) will invest approximately $1.7 billion in transmission system upgrades to improve reliability and increase power availability in states throughout the PJM footprint including Indiana, Maryland, Ohio, Virginia, and West Virginia. The companies' proposals were selected by the PJM Board to address forecasted conditions that would create reliability concerns.

"Energy demand is growing at a pace our nation has not seen in decades. Building or upgrading our infrastructure to continue delivering reliable power is essential to fueling economic growth and meeting the needs of our customers," said Bill Fehrman, AEP president and chief executive officer. "Our experience building the largest transmission system in North America made us an ideal candidate to help address the needs that PJM identified during their planning process. Our teams are ready to get to work engaging with our communities and stakeholders and are excited about being part of powering additional economic development opportunities in the region."

$1.7 BILLION OF TRANSMISSION INVESTMENTS

These projects were proposed through the Regional Transmission Expansion Plan (RTEP) process. Through the RTEP process, PJM asks transmission developers to submit project solutions to address transmission system needs and then selects the proposals that offer optimal solutions. PJM is seeking projects in this window to be in service in 2029. →

[1] AEP participates in the competitive transmission space through Transource Energy, LLC, a jointly owned transmission company with Evergy, Inc., headquartered in Kansas City, Missouri. AEP owns 86.5% interest in Transource Energy.

AEP submitted project proposals last year with solutions ranging from constructing new lines and new stations to upgrading existing power lines and replacing existing substation equipment. Collectively, these projects are crucial for ensuring reliable electric service, maintaining affordability and meeting future energy demands.

Of the $1.7 billion of investments, approximately $1.1 billion will be advanced through Transource Energy as part of a joint venture with Dominion Energy and FirstEnergy Transmission, LLC. The joint venture, Valley Link Transmission Company, LLC, was selected to develop several competitive transmission projects, including two 765 kilovolt transmission lines in West Virginia, Virginia, and Maryland.

The remaining $600 million in projects were approved for AEP's Transmission Companies and operating companies in Indiana, Ohio and Virginia. All projects are in the early stages of development and the company is committed to collaborating with residents, local governments and other stakeholders in the project communities at every stage of the process. Engagement with stakeholders about the benefits of these projects is crucial as decision-making and planning progresses.

$600
MILLION
IN PROJECTS

هيئة كهرباء ومياه دبي
Dubai Electricity & Water Authority

DUBAI ACHIEVES WORLD'S LOWEST ELECTRICITY CUSTOMER MINUTES LOST (CML) AT 0.94 MINUTES PER YEAR, BREAKING ITS 2023 RECORD

February, 2025

HE Saeed Mohammed Al Tayer, MD & CEO of Dubai Electricity and Water Authority (DEWA), announced that DEWA achieved the world's lowest electricity Customer Minutes Lost (CML) in 2024, recording just 0.94 minutes per customer. This breaks its record of 1.06 minutes in 2023 and is significantly lower than the 15-minute average of leading European utilities.

"We are guided by the vision and directives of His Highness Sheikh Mohammed bin Rashid Al Maktoum, Vice President and Prime Minister of the UAE and Ruler of Dubai, to make Dubai the world's best city for quality of life. To achieve this, we continuously develop Dubai's electricity and water infrastructure through innovation, which we adopt as a key approach to managing facilities through a smart and interconnected network. This enables us to deliver our services according to the highest standards of quality, availability, reliability, efficiency and sustainability, supporting the Dubai 2040 Urban Master Plan and the Dubai Economic Agenda (D33), which aims to position Dubai among the world's top three cities. We have reduced the Customer Minutes Lost in Dubai from 6.88 minutes per year in 2012 to just 0.94 minutes in 2024. This emphasises our leadership in innovation and adopting the latest disruptive technologies of the Fourth Industrial Revolution to enhance DEWA's resilience, agility and readiness to meet the growing demand for electricity and water in Dubai," said HE Saeed Mohammed Al Tayer.

> *"The Smart Grid, which we are implementing in stages with AED 7 billion investments up to 2035, has been instrumental in achieving this milestone. It provides advanced features, including enhanced energy transmission and distribution efficiency, reduced losses and improved electric load management. A key programme launched under the Smart Grid is the Automatic Smart Grid Restoration System, the first of its kind in the Middle East and North Africa. It increases the control, management and monitoring of the power network. Operating around the clock without human intervention, it uses smart, innovative and centralised systems to locate faults, isolate them and automatically restore service, enhancing grid automation, fault detection and rapid service restoration," added Al Tayer.*

CUSTOMER MINUTES LOST AT 0.94 MINUTES PER YEAR

Natural Resources Canada

GOVERNMENT OF CANADA CELEBRATES LAUNCH OF THE $5-BILLION INDIGENOUS LOAN GUARANTEE PROGRAM

February, 2025

Indigenous Peoples, communities and businesses are building a more sustainable and resilient natural resource sector in Canada. The Government of Canada is supporting Indigenous participation in the natural resource economy, helping to eliminate historic barriers and open doors for Indigenous groups to share in the economic benefits of resource and energy development.

Today, the Honourable Jonathan Wilkinson, Minister of Energy and Natural Resources, celebrated the launch of the $5-billion Indigenous Loan Guarantee Program while announcing an additional $6.2-million investment in seven Indigenous-led energy and forestry projects in British Columbia through the Indigenous Natural Resource Partnerships (INRP) program.

The Canada Indigenous Loan Guarantee Corporation was launched in December and is open for business, supporting Indigenous groups in benefiting from the economic opportunities of natural resource development. It will provide up to $5 billion in Indigenous loan guarantees to help unlock access to the capital needed for Indigenous groups to pursue ownership in natural resource and energy projects.

Loan guarantees work by providing a guarantee that the debt will be repaid by the guarantor (the federal government) should the borrower be unable to repay, which lowers the interest rate on the loan. Loan guarantees will help enable Indigenous communities and businesses to access private financing and to become meaningful equity partners and owners of natural resource and energy projects.

Indigenous Peoples in Canada are among some of the most innovative leaders in the natural resources sector. The Government of Canada has been promoting the economic participation of First Nations, Métis and Inuit Peoples for years by providing tangible support for Indigenous-led projects. Minister Wilkinson took the opportunity today (Feb 21) to also announce additional INRP funding for projects in B.C.

The INRP program is helping Indigenous communities across Canada to secure economic opportunities from projects and become equal partners in the resource economy. With the investments made today, for example, Fort Nelson First Nation in Northern B.C., is developing the Tu Deh-Kah (TDK) project, a 100-percent Indigenous-owned project that will be the first geothermal facility in the province and among the first in Canada. It will power 10,000 homes and create economic opportunity for the community.

There is much more work ahead to ensure that Indigenous Peoples will be equal partners in the development of energy and natural resources in Canada, and the Government of Canada remains committed to doing that work. Through advancing meaningful partnerships with Indigenous groups and enabling the development of innovative natural resource projects, together we are building good projects that will power and supply our communities and produce economic benefits for generations to come.

> ***"Today, as we celebrate the launch of the Indigenous Loan Guarantee Program, I want to thank the many Indigenous groups, businesses and organizations that have advocated for this over many years. It is thanks to their advocacy that Indigenous communities will have greater opportunities to build and share in the economic benefits of natural resource and energy development in their own ways and on their own terms. This will create jobs, drive economic growth and wealth, and have lasting impacts for the generations to come."***
>
> ***The Honourable Jonathan Wilkinson***
> *Minister of Energy and Natural Resources*

"INRP funding has increased the fluency of our members in climate change causes, impacts and mitigation and adaptation strategies. As a result, FNCI is advancing Indigenous natural resource development opportunities and building the decarbonized economy of the future. This includes enabling the pursuit of equity ownership in renewable energy infrastructure in northwest B.C.; the development of hydrogen and solid carbon manufacturing in the Port of Prince Rupert; and shaping the viability of Indigenous nature-based solutions projects from the Montney Play to the northwest coast. FNCI's partnership with Columbia University is an applied research project intended to activate specific decarbonization opportunities in Asian markets that result in measurable and transparent emission reduction benefits and agreements."

Chief Crystal Smith
First Nations Climate Initiative, Nisga'a, Haisla, Metlakatla, Halfway River First Nations

"The TDK Geothermal Energy Project is a vital step toward energy security and reliability in northeastern BC. Showcasing Indigenous leadership in Canada's geothermal industry, the project is 100-percent owned through Fort Nelson First Nation's economic development arm, Deh Tai LP. We are progressing in project design, permitting, consultation and BC Hydro negotiations. We are proud to lead the way in advancing sustainable, renewable energy solutions for our people and the broader economy."

Jim Hodgson
CEO, Deh Tai Limited

"For generations, Indigenous people have understood how to care for these landscapes, but that knowledge was pushed aside. Now, as we face growing wildfire risks, we're seeing a shift back to the practices that have always worked. This funding allows WLFN to lead the way training our people, reducing fuel loads and restoring balance to the land. It's a step forward, and there's still more work to do to have a resilient land base."

John Walker
Stewardship Forester, Williams Lake First Nation

Quick facts

- The Canada Indigenous Loan Guarantee Corporation is a subsidiary of the Canada Development Investment Corporation (CDEV) and was officially launched in the 2024 Fall Economic Statement.
- The number of major natural resource and energy projects with potential for Indigenous equity participation is anticipated to grow significantly, with the First Nations Major Projects Coalition's research expecting this potential to reach $525 billion in capital investment over the next ten years.
- Natural Resources Canada will support eligibility screening and deliver funding to help Indigenous groups obtain advisory services so they can make informed decisions on equity ownership opportunities in natural resource and energy projects.
- Historically, Indigenous Peoples have been excluded from Canada's natural resources sector. For example, due to the Indian Act, Indigenous communities have fewer options for securing capital or leveraging existing assets as collateral, leading to increased borrowing rates that create a barrier to equity investment in natural resource and energy projects.

REFLECTING ON INDUSTRY TRENDS

ELISABETH MONAGHAN
Editor in Chief

As we move into the second quarter of the year, this is a good time to reflect on how well electric energy experts did with their wrap-up of 2024 industry trends and predictions of what to expect in 2025.

With the rapid pace of technological change, especially in the utility space, predicting the future of electric energy has never been easy. This year, it may be even more difficult. Not only must the utility sector address ongoing issues like aging infrastructure, growing energy demand and rising energy costs, but there is also a significant shift in the political landscape in the United States, adding further uncertainty to the situation.

Political shifts: The Biden to Trump transition

The transition from the Biden Administration to the Trump Administration has brought a stark contrast in leadership approaches to electric energy. President Trump's policies, particularly in his second term, reflect a focus on fossil fuels and resistance to advancements in the alternative energy sector. Key actions have included:

- Suspending offshore wind development permits.
- Halting funding for clean energy initiatives under the Inflation Reduction Act.
- Pushing for increased fossil fuel production.

Impact on the energy sector

As a result of these changes, the energy landscape is filled with uncertainty. The imposition of 10% tariffs on Canadian energy products by the Trump Administration has raised concerns among consumers and investors about the potential effects on the U.S. economy. With electricity consumption predicted to rise and energy prices continuing to soar, it's no wonder that consumers are feeling increasingly anxious.

Decline in consumer confidence

Further complicating the situation is the significant decline in consumer confidence. According to The Conference Board, February of this year saw the largest monthly drop in consumer confidence since August 2021. Stephanie Guichard, senior economist at The Conference Board, explained that consumer pessimism is growing, particularly regarding future business conditions, employment prospects and income expectations. This sense of uncertainty is not just confined to the energy sector but is affecting the broader economy as well.

Maintaining momentum

Despite the challenges, there are some positive aspects to this situation. Events like DISTRIBUTECH, CIGRE and those hosted by IEEE continue to draw record crowds of industry partners. Case in point, there were 17,000 attendees at DISTRIBUTECH 2023, with the number increasing slightly in 2024. The 2024 IEEE PES T&D conference drew over 13,000 participants from more than 70 countries, which is up from the 2022 conference which drew 10,450 participants representing 63 countries.

This is a strong indication that international momentum for the energy transition continues, and that there is no sign of the renewable energy industry grinding to a halt.

The energy transition is inevitable

In this issue's *Powherful Forces* column, we profile Susan Stone, CEO of startup company Blue Current Energy. In the context of upcoming challenges due to Trump's focus on fossil fuels, including his signed "Unleashing American Energy" executive order, Stone's insights are particularly relevant. When I asked whether she was concerned about the Trump Administration's policies affecting Blue Current or the push towards grid modernization in general, Stone responded by emphasizing that energy, by its very nature, will continue to move forward. The energy transition, she believes, is inevitable.

You can read the full interview with Susan Stone on page 62.

Fossil fuels in the U.S. and the global energy transition

This year promises to be an interesting one with Donald Trump's return to the White House. We will see how electric energy providers, industry partners and consumers react to the Trump Administration's stance on fossil fuel versus alternative energy, and whether it will affect the global market. If Trump once again pulls out of the Paris Agreement, the remaining participants, representing approximately 200 countries from around the globe, will continue to push towards net-zero carbon emissions by 2050.

The future of fossil fuels will likely depend on the success of the global energy transition to cleaner energy. To compete on a global level, the U.S. must continue to keep pace with the rest of the world in terms of the type of energy it produces. If the industry is encouraged to shift back to prioritizing fossil fuels, it must not cast aside past efforts on renewable energy.

In a few months, we will see how industry predictions played out, examine the latest trends and assess where the U.S. stands on its grid modernization efforts compared to the rest of the developed countries.

As always, if you would like to contribute an article on an interesting project, please email me:

Elisabeth@ElectricEnergyOnline.com

Elisabeth

IMPLEMENTATION OF AN AUTOMATED VISUAL AND THERMAL MONITORING SYSTEM IN EXTRA HIGH VOLTAGE (EHV) SUBSTATION

FOR EARLY DETECTION OF FAILURE MODES USING ANALYTICS

EDDIE VILLA, LEONARDO GONZALEZ, EDGAR SOTTER

1. Introduction

The efficient operation and maintenance of electrical substations are crucial to ensuring reliable energy supply. In recent years, the increasing complexity and demands on electrical infrastructure have highlighted several challenges in substation monitoring and maintenance. Traditional methods often fall short in providing the necessary real-time insights and early warnings needed to prevent failures and ensure continuous operation. The implementation of advanced monitoring technologies, such as automated visual and thermal systems, represents a significant advancement in addressing these challenges.

The focus substation is located in Santa Marta, Colombia, and plays a vital role in the regional power distribution network. The company is a leading Colombian organization dedicated to the transmission of electricity, ensuring reliable and efficient energy supply across the country.

This project focuses on an extra high voltage substation, where an automated system integrating high-resolution PTZ, thermographic and IoT cameras were deployed. The system's objective is to enhance the remote monitoring capabilities, allowing for timely detection of thermal anomalies and other failure modes through advanced analytics. This paper details the system components, their installation and observed benefits, including specific instances where early detection of anomalies prevented potential failures and significant financial losses. The integration of these technologies into the existing SCADA system further supports remote decision-making and operational efficiency. →

2. Challenges in substation monitoring

The operation and maintenance of electrical substations are essential to ensure reliable energy conditions. Over the years, various challenges have emerged, driving the need to seek more advanced solutions. The following are some of the challenges experienced in monitoring electrical substations:

2.1. Challenges in early detection of thermal anomalies

Electrical substations are subject to a variety of failure modes and abnormal conditions that can jeopardize operation and safety. Identifying these anomalies early is challenging but crucial to avoid unplanned interruptions and equipment damage. Thermal anomalies can result from issues such as contact problems, irregular loads, insulation cracks defective relays. These issues increase the internal temperature of electrical equipment, leading to shortened life expectancy of the asset, unexpected disturbances and potential damage to power systems.

Specific examples of where these issues can occur include:

- **Transformers:** Overheating in transformers can be caused by insulation failures or issues with the cooling system. Identifying hotspots early is critical to prevent transformer fires and extensive damage.
- **Circuit Breakers:** Contact problems in circuit breakers can lead to localized heating. If left undetected, this can cause the breaker to malfunction, resulting in outages or equipment damage.
- **Busbars:** Irregular loads and poor connections at busbars can create thermal anomalies. Ensuring even load distribution and secure connections are essential to avoid overheating.
- **Cables and Connectors:** Defective relays or improper connections in cables and connectors can cause significant temperature rises. Regular monitoring is required to prevent cable insulation damage and potential failures.
- **Switchgear:** Insulation cracks in switchgear can lead to partial discharge and thermal anomalies. Early detection helps in maintaining the integrity and functionality of the switchgear.

Two factors make early detection of thermal anomalies particularly challenging:

- **Manual Inspection Limitations:** Manual inspection of infrared images requires experienced engineers to check and judge the collected images one by one. This process is not only time-consuming but also prone to human error, making it difficult to consistently identify thermal anomalies[1].
- **Complexity of Equipment:** Substations contain a variety of equipment with different thermal characteristics. The complexity and diversity of these components make it challenging to set uniform criteria for anomaly detection and require tailored approaches for different types of equipment[2].

Early detection using infrared thermography is essential to prevent equipment failure and ensure the reliability of the power grid. However, these challenges must be addressed to improve the accuracy and effectiveness of thermal monitoring in substations.

2.2. Inaccessibility to critical areas

Some areas of electrical substations can be difficult or even dangerous for personnel to access. This inaccessibility can hinder the inspection and maintenance of equipment in critical areas, leading to poor supervision. Specific examples of inaccessibility challenges include:

- **High-Voltage Areas:** Areas near high-voltage equipment, such as transformers and circuit breakers, can be hazardous to access without appropriate safety measures. Personnel must navigate around energized components, increasing the risk of electrical hazards[3].
- **Confined Spaces:** Substations often have confined spaces where equipment like switchgear is installed. These areas are challenging to access and require specialized training and equipment to ensure safe entry and exit.
- **Environmental Conditions:** Adverse weather conditions, such as extreme heat, cold, or storms, impact the accessibility of outdoor substations. Dust and debris can also obstruct pathways and make it difficult to perform inspections and maintenance tasks.

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[1] M. Lu, H. Liu X. Yuan, "Thermal fault diagnosis of electrical equipment in substations based on image fusion," *Thermal Science*, vol. 25, no. 2, pp. 3804-3812, 2021.

[2] Maintworld, "Using Ultrasound and Infrared for Electrical Inspections: Examples," Maintworld, 2023. [Online]. A vailable: https://www.maintworld.com/

[3] DCIGRE, "Life-long Supervision and Management of Substations by use of Sensors, Mobile Devices, Information and Communication Technologies," CIGRE, 2023. [Online]. Available: https://www.cigre.org/

- **Complex Layouts:** The intricate layout of substations, with multiple interconnected components, makes it challenging to reach certain areas. This complexity requires careful planning and execution of maintenance activities to avoid disrupting operations.

2.3. Need for continuous supervision

Substations operate 24/7 and require continuous supervision to ensure optimal functioning. The increasing complexity of electrical networks and the integration of distributed energy resources necessitate constant monitoring to maintain reliability and address any issues promptly. Continuous condition monitoring using sensors and advanced technologies provides real-time data on critical variables such as temperature, humidity and electrical parameters. This data helps in early detection of potential failures, enabling timely maintenance and reducing the risk of unplanned outages[4-5].

Additionally, the growing demand for electrification, such as electric vehicles (EVs) and renewable energy sources, has increased the load on electrical substations. These changes in load over time can create new challenges for substation management. For example:

- **Load Variability:** The integration of renewable energy sources like solar and wind introduces variability in the power supply, requiring substations to manage fluctuating loads efficiently.
- **Increased Demand:** The adoption of electric vehicles and the expansion of EV charging infrastructure place additional demand on substations, necessitating upgrades and enhanced monitoring to handle the increased load.
- **Grid Stability:** The rise in distributed energy resources requires substations to maintain grid stability and ensure the seamless integration of various power sources, which can be complex and demand continuous oversight.

Overall, the need for continuous supervision is driven by the dynamic nature of modern electrical grids and the critical role of substations in maintaining reliable and efficient power distribution.

3. System description

The implementation of an automated visual and thermal monitoring system represents a significant technological advancement in substation monitoring. This system integrates a variety of advanced components and sensors that enable advanced, real-time supervision, detecting anomalies and generating automated responses. Below is a detailed description of the key aspects of the implemented system.

3.1. System components

The automated monitoring system comprises several essential components that work together to provide comprehensive and effective substation supervision:

3.1.1. Visual monitoring sensors: Visual monitoring sensors (**Figure 1**) are essential for capturing high-resolution images of equipment, connections critical areas within substations. These sensors provide detailed visual information for remote inspection and analysis problem detection. To ensure reliable operation in harsh substation environments, these sensors must comply with IEC61850-3 standards. Enhanced features such as smart infrared capabilities for night vision, automated patrolling presets multiple presets for video analytics with intelligent motion detection functions improve their functionality. These features enable real-time visualization and remote inspection, making them crucial for safety and security asset monitoring in challenging conditions. →

Figure 1. Pan-Tilt-Zoom Cameras used to monitor operations and asset conditions.

[4] MEP-Projects, "Predictive Maintenance in Electrical Substations," MEP-Projects, 2023. [Online]. Available: https://www.mepprojects.com/

[5] EEP - Electrical Engineering Portal, "Substation control and monitoring systems: The eyes and ears of every power system," EEP, 2023. [Online]. Available: https://www.electrical-engineering-portal.com/

3.1.2. Thermal infrared sensors: Thermal sensors (**Figure 2**) are essential for detecting temperature anomalies in electrical equipment and systems by capturing infrared light emitted by objects, which is invisible to the human eye. These sensors, equipped with mobility systems and communication capabilities via the IEC61850 protocol, are crucial for identifying hotspots and incipient failure modes. They facilitate the detection of overheating and hot spots by capturing temperature-based images and data. Additionally, thermal sensors offer multiple presets, allowing the configuration of different regions of interest per preset and generating temperature readings and thermal alarms associated with each analyzed object, enhancing their functionality and precision. These sensors must be able to operate reliably under harsh conditions, including high levels of EMI, ESD, voltage surges temperature extremes.

Figure 2. Thermal-visual sensors on Pan-Tilt units for automated asset monitoring and detection of hot spots.

3.1.3. Onsite servers: Onsite servers (**Figure 3**) are crucial for substation monitoring and managing storing data from various sensors and cameras. Local analysis and storage of video and thermal data minimize the use of bandwidth on the operations network and improve system reliability in case of network failures, ensuring continuous, dependable monitoring and alarm notification under challenging conditions. These servers must be designed and built to withstand harsh substation conditions, with no fans or moving parts be equipped with industrial-rated power supplies and solid-state drives. Complying with IEC61850-3 and IEEE1613 standards ensures reliable operation in environments with high levels of EMI, ESD, voltage fluctuations extreme temperatures.

Figure 3. Substation hardened servers used for local video and data analysis and storage.

3.1.4. IoT sensors: These sensors (**Figure 4**) play an essential role in monitoring confined spaces within substations, such as inside switch gears or underground vaults. These sensors provide both thermal and visual data, enhancing situational awareness and asset health management in these challenging environments. These sensors must be designed for electric power applications and must be able to operate reliably under harsh conditions, like high levels of EMI and ESD voltage surges.

Figure 4. IoT sensors used for visual and thermal asset monitoring.

3.1.5. Communication systems: All cameras and sensors used in the system are equipped with communication systems that enable real-time data transmission based on the IEC61850 standard to a SCADA interface located in a control center. This facilitates remote supervision and decision-making.

3.1.6. Control platform: A software-based control center (**Figure 5**) provides the user interface for monitoring and controlling the sensors, visualizing data receiving alerts in case of anomalies.

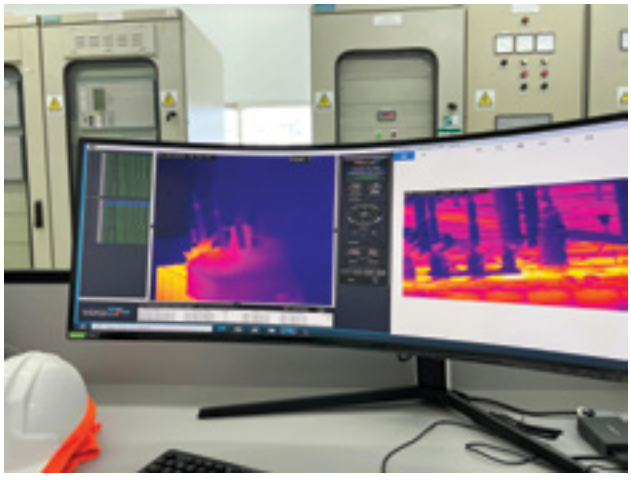


Figure 5. Control platform of the remote automated monitoring system at Substation.

3.2. System Architecture

The system was designed to deliver analytical signals to the substation's main controller for supervision across various operation levels. The video server not only delivers signals to the local system but also provides real-time video to the control center.

The primary goal of sensor placement is to efficiently supervise and analyze the maximum number of assets and equipment, thereby optimizing resource implementation. The system incorporates three thermal sensors with analytics, covering 576 thermal tracking positions, which monitor 96% of the substation's power equipment. Thermographic sensors for equipment supervision are strategically located to ensure their visual field includes the substation's transformers.

Additionally, six visual cameras with 1152 viewing positions have been installed. These cameras can be remotely accessed via SCADA for visualization or from the central monitoring station or the substation's HMI monitoring. This setup offers significant benefits, including estimated savings on night trips to the substation for verifying maneuvers in robotized metal-clad cells. The placement of these cameras was determined to support operations by providing the control center with a clear view of remotely executed maneuvers. **Figure 6** shows the overall architecture of the solution. →

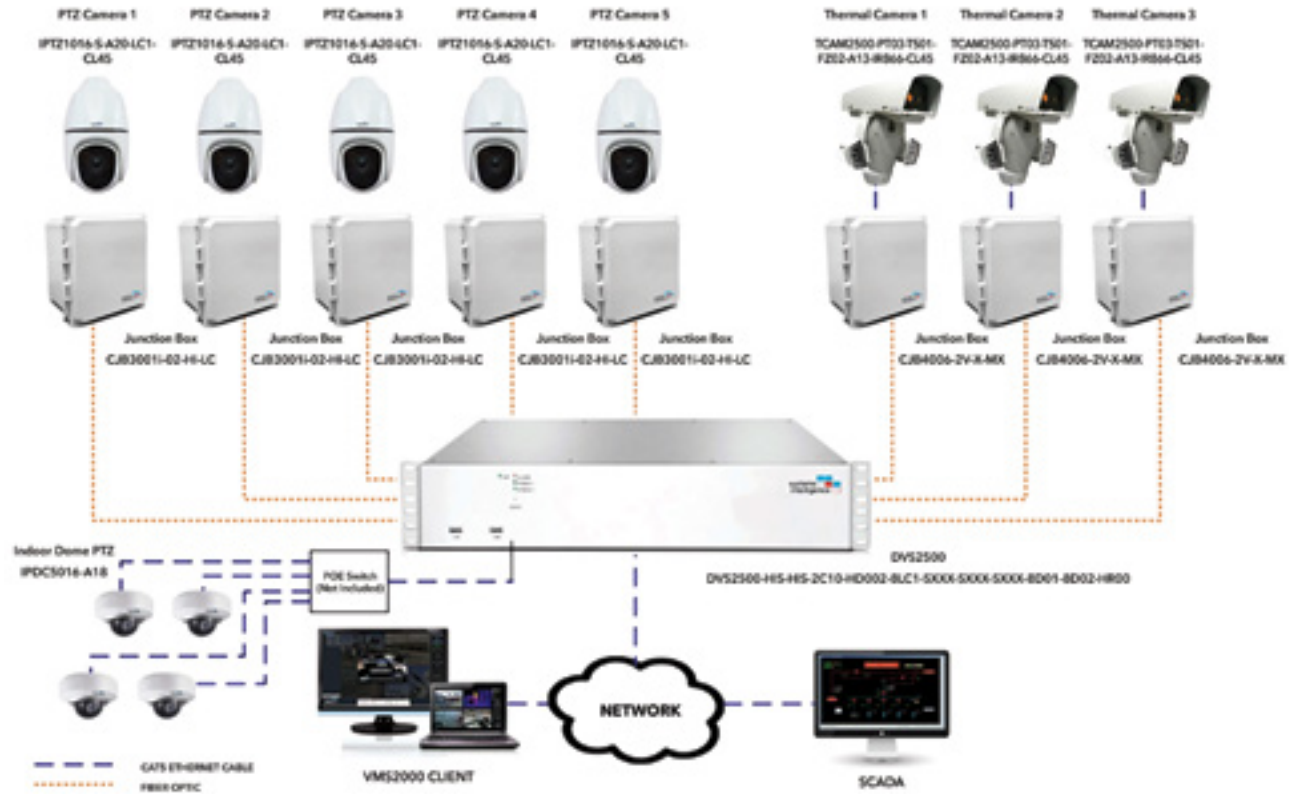


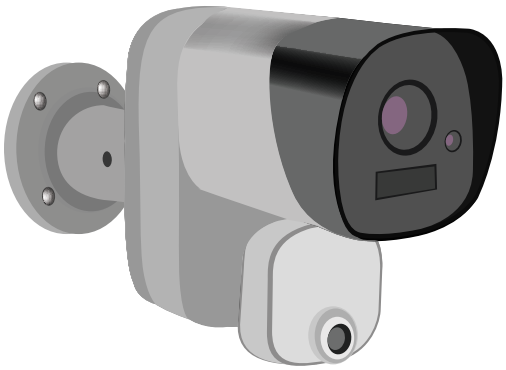
Figure 6. Architecture of the remote automated monitoring solution implemented.

4. Results.

Early detection of thermal anomalies in critical power system components was successfully achieved, leading to significant preventive measures and cost savings:

- **34.5 kV Bushing of a 220/110/34.5 kV 100 MVA Transformer:** An initial thermal anomaly was identified in the internal part of the bushing. Failure to detect this early could have resulted in a potential fire risk to the transformer, with estimated costs of approximately US$2.5 million.
- **34.5 kV XLPE Power Cable Terminals:** Early detection of thermal anomalies in these terminals allowed for scheduled normalization. This preventive action avoided potential failures or emergency de-energization, which could have led to unmet demand and operational disruption due to the outage of the 220/110/34.5 kV 100 MVA transformer.
- **13.8 kV Metalclad Cell at Circuit Exit in XLPE Cable Connection:** A thermal anomaly was detected internally, preventing a failure with an estimated potential impact of US$70,000.

These anomalies were promptly reported through the substation's Supervision and Control System (SSC) and communicated via email to the designated engineers, ensuring timely intervention and mitigation of risks.



5. Conclusions and recommendations

The implementation of an automated visual and thermal monitoring system at the Substation has demonstrated substantial benefits in enhancing the reliability and efficiency of substation operations. By integrating high-resolution PTZ and IoT cameras with thermographic sensors, the system has significantly improved the early detection of thermal anomalies and other potential failure modes. The advanced analytics and real-time data transmission to the SCADA system have enabled rapid and informed decision-making, ultimately preventing costly failures and ensuring uninterrupted power supply.

Key achievements of the project include the successful identification of critical thermal anomalies, such as the initial thermal anomaly in the 34.5 kV bushing of a 100 MVA transformer, which averted a potential fire hazard and significant financial loss. The proactive detection and timely response to issues in power cable terminals and metal-clad cells further highlight the system's efficacy in maintaining operational integrity.

The integration of these advanced monitoring technologies offers a robust solution for remote substation supervision. The project's success underscores the importance of continuous innovation and the adoption of cutting-edge technologies in the energy sector to address evolving challenges and ensure the stability of power distribution networks.

Future recommendations include the expansion of such automated systems to other substations within the network, continuous improvement of the analytics algorithms for even more precise anomaly detection and the exploration of additional IoT-based solutions to further enhance the scope and depth of substation monitoring. These steps will contribute to the overarching goal of achieving a resilient and reliable electrical infrastructure capable of meeting the growing demands of modern energy consumption.

The project's success underscores the importance of continuous innovation and the adoption of cutting-edge technologies in the energy sector to address evolving challenges and ensure the stability of power distribution networks.

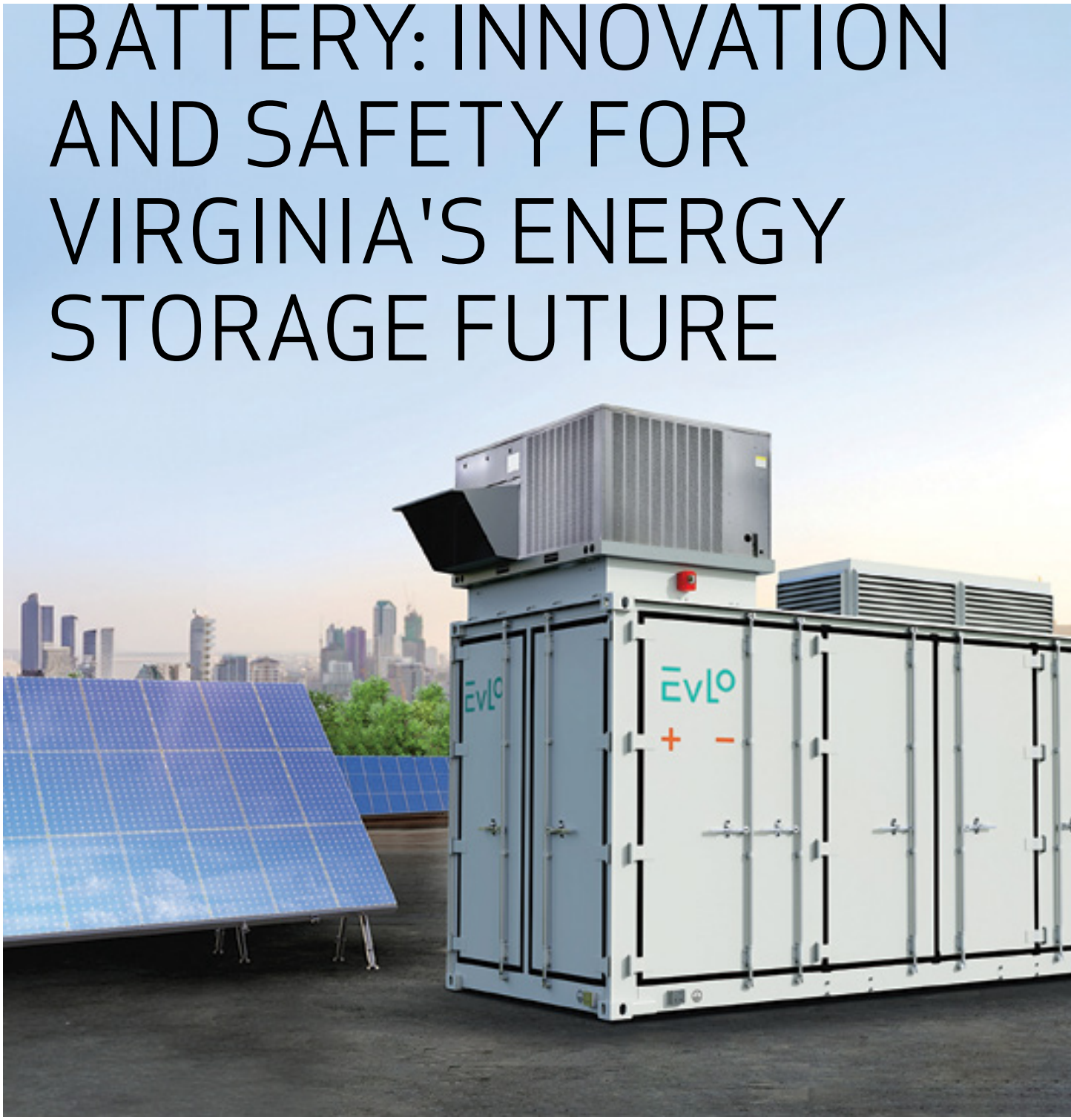
ABOUT THE AUTHORS:

Eddie Villa has 26 years of experience in the management of medium, high extra high voltage electrical energy transmission systems on the Colombian Atlantic Coast, working in the areas of planning, programming, evaluation, control and maintenance management and leader of the implementation of the asset management system under the PASS 55 and ISO-55001 standard for substations and transmission lines. He currently holds the position of coordinator of the planning and evaluation of the maintenance of substations and transmission lines at TRANSELCA, leading the implementation of new technologies to monitor critical assets in substations and transmission lines to solve challenges at the operation of the high-voltage electrical grid. Additionally, he is a frequent panelist and speaker at industry events. He earned his MBA at Universidad del Norte, Colombia. Specialist at Transmission of electrical energy and has a Bachelor of Science in electrical engineering from Universidad del Norte, Colombia.

Leonardo Gonzalez, who is a specialist in industrial automation and electronic engineering, has 14 years of experience in the development of projects in low, medium, high extra high voltage electrical energy transmission, distribution and generation critical industrial systems over Latin America, working in the areas of projects, sales, protection and control automation. He currently holds the position of director of sales, LATAM in Systems With Intelligence Inc., leading the implementation of new technologies to monitor critical assets to improve the system performance in substations and transmission lines to solve challenges at the operation of the high and medium voltage electrical grid over 19 countries in Latin America region. Gonzalez is a frequent speaker at energy sector events. He earned his specialist course in industrial automation at Universidad Distrital Francisco Jose de Caldas, Colombia and a Bachelor's in electronic engineering from Universidad del Magdalena, Colombia.

Edgar Sotter has 20 years of experience in implementing technology-based solutions, primarily in the electric sector. He has been instrumental in developing IoT products and SaaS platforms to monitor critical assets within this sector. Sotter has numerous publications addressing the use of technology to solve industry challenges. Additionally, he is a frequent panelist and speaker at industry events. He earned his MBA from the Rotman School of Management at University of Toronto, Canada, a Ph.D. in electronic engineering from Universitat Rovira i Virgili in Tarragona, Spain and a Bachelor's in electronic engineering from Universidad del Norte, Colombia.

BEYOND THE BATTERY: INNOVATION AND SAFETY FOR VIRGINIA'S ENERGY STORAGE FUTURE



Dominion Energy has chosen EVLO's EVLOFLEX battery energy storage system for its reliable performance and robust safety features. In 2025 and 2026, three energy storage projects, totaling over 300 MWh, will be deployed across Virginia. Source: EVLO Energy Storage Inc.

JON SORENSON AND MARTIN RHEAULT

The global push toward clean energy presents today's utilities with unprecedented challenges: modernizing aging grid infrastructure, integrating intermittent renewable sources and maintaining reliability amid extreme weather events and surging electricity demand.

The impact of this transition is particularly apparent in the Commonwealth of Virginia, where converging forces are reshaping the energy landscape for utilities. The Virginia Clean Economy Act (VCEA) mandates that utilities sunset traditional power plants and achieve 100% carbon-free electricity by 2050. Electricity demand is increasing, especially in Northern Virginia, the world's largest data center market. Home to more than 35% of all hyperscale data centers worldwide, Northern Virginia's data centers represent 13% of global operational capacity. Data centers consume massive amounts of electricity, already making up an estimated 25% of Virginia's total electricity demand. Meanwhile, Virginia has experienced an increased number of severe storms, cyclones and other extreme weather events that threaten grid reliability. From 2020 to 2024, the state experienced an average of $8 billion-dollar weather disasters annually, almost three times the long-term annual average.

This combination of rapid electricity demand growth, diversified energy resources and increasing extreme weather demands that utilities quickly and decisively invest in robust and reliable power infrastructure. Faced with these mounting grid pressures, Virginia's utilities are implementing solutions at an industry-leading scale.

Dominion Energy is the largest utility in Virginia, covering a service area spanning much of the eastern part of the Commonwealth. The utility predicts that electricity demand in its service territory will double by 2039. VCEA has also mandated Dominion Energy to deliver 100% renewable electricity by 2045 while requiring the development of 2,700 megawatts (MW) of energy storage capacity in the Commonwealth by 2035. →

Dominion Energy is the largest producer of carbon-free electricity in New England. In its 2024 Integrated Resource Plan, the company outlines significant investments in new power generation, grid modernization, energy storage and efficiency programs to meet rising power demand. Source: IStock

Dominion Energy: Transforming Virginia's grid

To achieve these targets, Dominion Energy is spearheading Virginia's regional grid transformation to create a smarter, more responsive network through a multi-billion-dollar clean energy and grid modernization strategy and 21 gigawatts (GW) of planned renewable energy development by 2039.

Critical to Dominion's success is deploying new battery energy storage systems (BESS), flexible, multifaceted grid assets that can allow operators to integrate renewable energy, enhance grid reliability and meet peak demand. In its 2024 Integrated Resource Plan, Dominion carved out a target of 4.5 GW of new BESS capacity by 2039 and immediately began to search for an integrator to design a storage system that would meet the utility's stringent safety specifications.

Dominion was already familiar with Hydro-Québec's subsidiary, EVLO Energy Storage, through early discussions with EVLO's development team about the utility's operational and safety requirements. These conversations led to the establishment of EVLO's Product Innovation Advisory (PIA) board, where existing and prospective customers are invited to provide market and user feedback. Through this collaboration, EVLO had already built a strong foundation of trust and transparency with Dominion, standing out with a utility-focused approach.

Building on their established relationship, the two organizations were well-positioned to work together to develop next-generation BESS solutions for optimal safety and performance in Virginia.

Shared utility DNA

In addition, EVLO brought an added layer of trust to its relationship with Dominion, built on their shared foundation in the utility sector. The company's approach to energy storage is deeply rooted in the heritage of its parent company, Hydro-Québec, a public utility managing the generation, transmission and distribution of electricity in Quebec. As Canada's largest power utility and North America's leading renewable energy producer, Hydro-Québec brings more than 80 years of operational expertise to EVLO's development process.

The integrator's "utility DNA" is further strengthened by Hydro-Québec's extensive research and development capabilities. Since establishing its research institute in 1970, the state-owned utility has maintained one of the industry's most comprehensive R&D operations, with over 500 experts working at the forefront of power system innovation. The utility's pioneering work spans decades, from developing 735 kV transmission systems in the 1960s to early breakthroughs and patents focused on the lithium iron phosphate battery technology in the 1990s.

Enhanced safety features

With 2.7 million electric customers in Virginia alone, Dominion requires stringent safety measures for its facilities to ensure service reliability and protect surrounding communities. EVLO's proactive commitment to comprehensive safety features made it an ideal match for Dominion's operational standards.

"Public safety is at the core of everything we do, so much so that we actively exceed existing safety regulations with our own stringent standards," explained Robert Hare, Manager of Construction at Dominion. "EVLO not only welcomed our safety requirements but exceeded expectations, collaborating with us to develop the safest, most cost-effective BESS solution possible. EVLO's rigorous approach involves multiple layers of protection to prevent safety incidents and ultimately minimize and mitigate any errors." →

> **Public safety is at the core of everything we do, so much so that we actively exceed existing safety regulations with our own stringent standards.**
>
> **- Robert Hare, Dominion Energy**

Hydro-Québec's research institute (IREQ), a beacon of innovation with a rich history in research and development. As a subsidiary of Hydro-Québec, North America's largest renewable energy producer, EVLO leverages its deep-rooted expertise in large-scale energy systems to meet the needs of utilities. Source: Hydro-Québec

EVLO's state-of-the-art 25 kV testing facility is connected to the distribution grid. It ensures enhanced reliability and safety for clients, delivering systems ready for seamless grid integration and real-world performance. Source: EVLO Energy Storage Inc.

For this collaboration, Dominion selected its EVLOFLEX BESS, which achieved UL 9540 certification for its comprehensive safety features. By design, EVLOFLEX employs lithium iron phosphate (LFP) chemistry, known for its longer cycle life, increased stability and safety and higher efficiency compared to other lithium-ion alternatives. EVLOFLEX also includes layers of protection at every level – from cell to enclosure – with both active and passive fire mitigation strategies that exceed NFPA 69 requirements, such as failsafe venting panels that operate even during power outages. Additional features, such as an internal container fire panel, sensors and horns, were added specifically to meet Dominion's requirements.

Notably, EVLO demonstrated its commitment to meeting Dominion's robust cybersecurity requirements – an important consideration given that Dominion's service territory includes critical federal infrastructure. While many manufacturers offer standardized products only, EVLO undertook a year-long process to further enhance its control and communication systems to meet Dominion's heightened security specifications.

Meeting Dominion's rigorous performance and safety specifications on paper was important, but real-life, grid-connected testing would be critical for validating the control compatibility of the system prior to installation.

Real-world testing for real-world challenges

At EVLO's live test line – one of the only facilities of its kind in North America – every safety feature of the augmented EVLOFLEX underwent rigorous testing on a live distribution network. This dedicated facility enables comprehensive validation of BESS performance under actual grid conditions.

"Our tests go beyond what is required," explains Jon Sorenson, who is responsible for North American Business Development at EVLO. "We are one of the only BESS companies in North America with a test line connected to a live distribution grid. We're constantly testing and troubleshooting, coming up with different ideas and processes. It's a true living lab."

This testing enables the identification of potential issues before commercial deployment, minimizing end-user risks and ensuring compliance with safety standards.

"When I've visited their facilities, I've been impressed by how thorough the EVLO teams are in testing and retesting their systems," said Hare. "They are diligent, thoughtful and thorough in their application of design changes. The result is a much higher level of confidence in the product and an expectation of reduced surprises during commissioning."

Through a meticulous process of design and testing, EVLO has successfully improved the safety and performance of EVLOFLEX, achieving predelivery certifications. The enhanced EVLOFLEX system incorporates a suite of advanced safety features such as external and internal fire control panels and redundant hazard detection systems. These measures not only meet Dominion's requirements and earned the augmented system a UL 9540 certification, but they also align with broader industry standards like NFPA 72.

Dominion worked closely with EVLO throughout the design process and UL certification, conducting extensive testing to achieve predelivery certifications that recognize BESS safety, reliability and performance.

"Dominion leads the way when it comes to fire and safety regulations," said Sorenson. "Their input was invaluable in refining the EVLOFLEX system to exceed even the most stringent safety requirements. The EVLOFLEX amended for Dominion is by far the safest product in the battery energy storage market."

Powering Virginia's clean energy transition

The successful collaboration between EVLO and Dominion will result in the deployment of more than 300 megawatt-hours (MWh) of amended EVLOFLEX BESS across three large-scale projects in Virginia. These systems, scheduled for commissioning in 2025 and 2026, are designed to ensure grid reliability while advancing the goals of the Virginia Clean Economy Act (VCEA).

The VCEA represents Virginia's most ambitious clean energy initiative yet. By mitigating the intermittency in renewable energy production, the EVLOFLEX systems will play a critical role in bolstering grid reliability throughout this transition.

"Public trust is built on the safety and reliability of the systems we deploy," said Hare. "EVLO's ability to meet our safety standards gives us confidence in their solutions."

ABOUT THE AUTHORS:

Jon Sorenson is responsible for North American Business Development at EVLO Energy Storage Inc., a fully integrated battery energy storage systems and solutions provider and subsidiary of Hydro-Québec, North America's largest renewable energy producer. His extensive experience in the energy industry spans traditional and renewable energy development, marketing, procurement, risk management and sustainability planning in the US and Canada.

Martin Rheault is vice president Business Development and Sales at EVLO Energy Storage Inc. For more than 20 years, Rheault has been advancing the energy transition with a focus on electricity, renewable energy and energy storage technologies. With a unique background in both technical and business expertise, Rheault brings his sharp strategic vision to accelerate the adoption of EVLO's innovative energy storage solutions across North America and abroad.

ADVANCING GRID MODERNIZATION

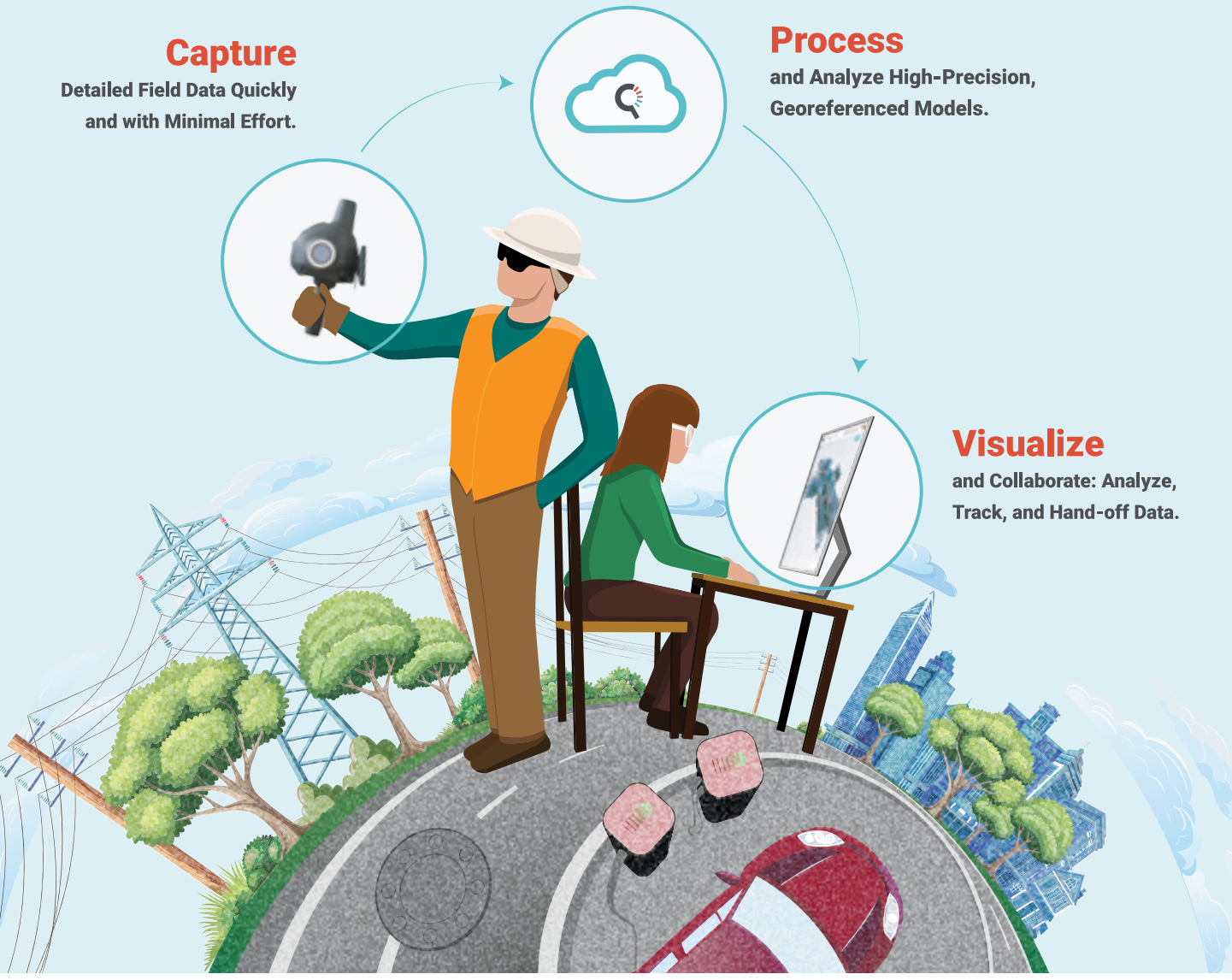
THROUGH INNOVATION, INDUSTRY RESEARCH, EARLY ADOPTERS

TERESA ELLIOTT

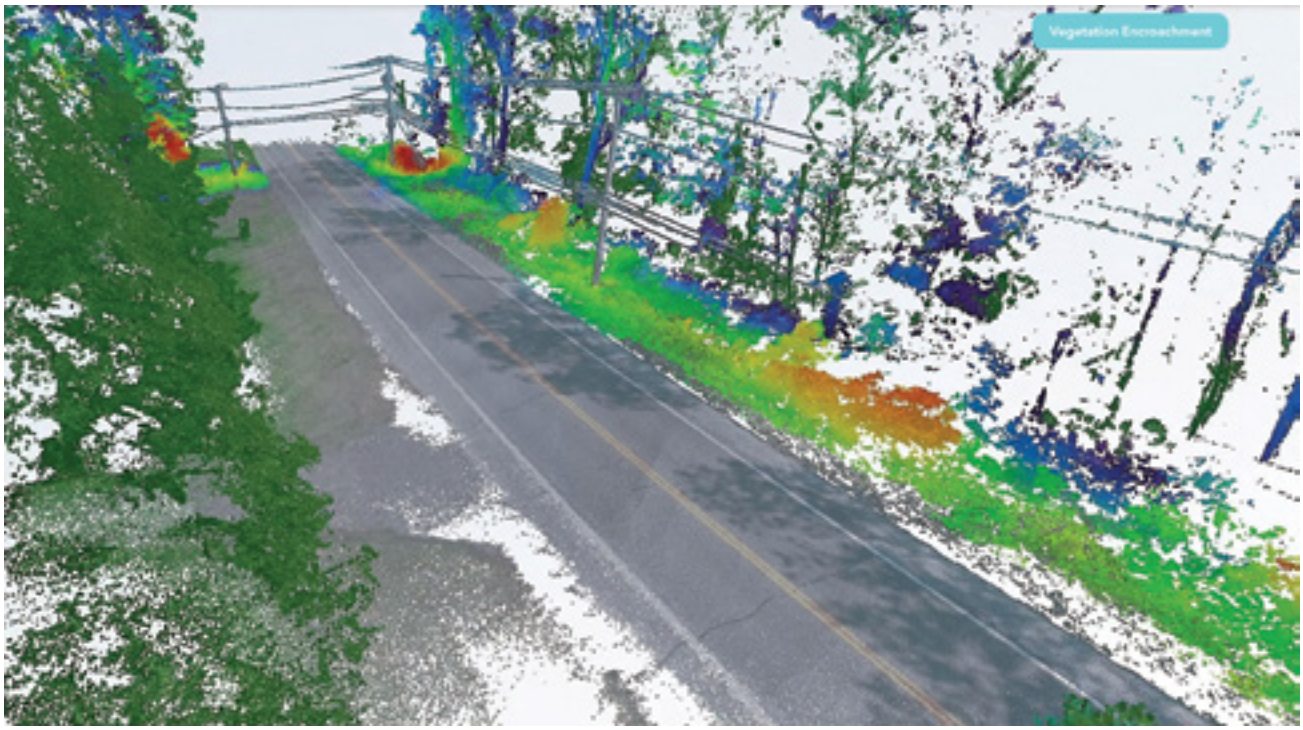
Imagine a university lab where students, professors and industry experts come together to develop an integrated hardware and software solution. This dynamic environment fosters innovation, with each participant bringing unique expertise. Ph.D. candidates collaborate with industry experts to design hardware and create software algorithms, testing their prototypes in real-world environments to develop viable industry solutions.

This collaboration between academia and commercial organizations leads to groundbreaking research and practical applications that benefit society. A similar collaborative spirit thrives in the utilities industry. Just as in academia, the utilities sector shows that working across functional boundaries leads to remarkable outcomes. Utilities can leverage internal teams, engineering partners, technology vendors and research organizations to drive innovation.

As electric utilities navigate the ever-increasing requirements to support sustainability, reliability, resilience and deal with workforce transitions and tech advancement, these evolving relationships within the engineering and technology ecosystem become crucial for innovation. Shifting from historical transactional interactions to integrated partnerships fosters continuous learning, technological advancement and mutual benefit. These collaborations enable utilities to minimize trade-offs between cost control and innovative investment. Working closely with research institutions and suppliers, utilities can refine workflows, enhance capabilities and drive greater overall success. One such example is Looq AI. Initially a university proof of concept, this solution evolved rapidly to early adopters. The goal is to enhance workflows with AI-enabled asset capture through strategic partnerships. Working with firms like Aquawolf and research organizations, Looq is helping the industry identify cost and time reductions compared to traditional surveys, fostering the rapid adoption of innovative solutions for a more sustainable and efficient utility system. →



Source: Aquawolf



To identify and address potential interruptions from overhead systems, feature classification and insights built into capture workflows can help to anticipate issues. Not only would this help to optimize work for greater crew efficiency and provide potential cost savings, but also it has the potential minimize customer interruptions leading to improved reslience. Source: Aquawolf

Modernizing data capture

The growing need for accurate, up-to-date records necessitates continuous capture and modern data management solutions. Historically, information was derived from original engineering drawings or outdated as-built records, requiring multiple field trips to capture existing conditions for upgrades. This process was (and still can be) labor-intensive, time-consuming and expensive. Today, advancements in capture technology, such as high-resolution digital cameras, drones and automated processing, have revolutionized the industry. Photogrammetry, combined with AI and machine learning, produces precise, cost-effective 3D models. These digital representations integrate high-resolution textures from photogrammetry and precise structural details from LiDAR. Innovative teams incorporating this captured data with GIS, engineering and IoT data into digital twin environments gain data-driven insights that enhance business outcomes. This justifies investment in digital transformation, facilitating seamless data sharing and integration across platforms.

Continuously updated digital twins lead to smarter utility infrastructure. Yet, despite the benefits, surveying areas that include millions of points and large datasets can still create a hefty price tag. Given that their systems are ever-changing, utilities may hesitate to invest in additional innovative technologies or change workflows. Partnerships with research organizations, engineering firms and software vendors can mitigate these costs and drive innovation. This collaborative approach allows utilities to leverage innovative technology while managing expenses and change effectively. And the results have the potential to be transformative.

Embracing new ways

Taking care of the grid is not simple or easy. Diverse needs and tools make the inspection and diagnosis of large infrastructure assets like distribution overhead fragmented, slow and laborious. In some instances, old-school tape measures and clipboards remain part of the process. All of this can result in fragmented survey and engineering, decisions made off information that is likely outdated. On average it takes about 60 minutes per pole survey. Considering the number of poles in North America, that extrapolates to about 200,000 man-years to survey the poles. And while surveying poles sounds simple, it is high touch – costly, error-prone and comes with a high risk of accident/injury.

> **This new approach speeds the process for pole fielding to approximately 250 poles/day – in some instances that is 10 times faster than traditional work.**

This new approach addresses asset capture and modeling in a complete and scalable way providing an unprecedented level of detail for survey, structural analysis, electrical verification, vegetation encroachment and GIS applications. The solution can improve fielding workflows at the start of a project, throughout construction, for handoff of as-builts and inspections and maintenance. This approach may in fact surpass what aerial, UAV and vehicle data collects can match because there are fundamental visibility and resolution limitations. This new approach speeds the process for pole fielding to approximately 250 poles/day – in some instances that is 10 times faster than traditional work. Looq claims this new approach provides post-processing/pole modeling three times faster. This means getting the updated information into the hands of decision-makers quickly and more efficiently.

For inspections and maintenance of utility assets, the working hypothesis for the solution is by accessing updated information more often (vegetation cycles or overhead equipment inspections that can happen more often without increasing crews) provides insights for prioritizing work and better scheduling. This, in turn, could help them to reduce the customer interruptions caused by tree contacts and overhead equipment failures. While Looq boasts about these improved workflow claims, they understand that the proof is in allowing others to evaluate and prove its accuracy and value. They are doing this directly with Central Hudson Gas and Electric as well as through early adopters like Aquawolf, McElhanney and AJS.

Piloting technology and new workflows

Research organizations can leverage the expertise, technologies and solutions to advance research and development in energy while benefiting from the specialized expertise of the vendors. Collaboration between electric utilities and their supplier ecosystem along with these research organizations can help to address challenges and augment technological advancement. These partnerships are crucial for moving theoretical research into practical, implementable solutions. For example, EPRI's Incubatenergy Labs program matches early-stage technology companies with electric utilities in pilot projects demonstrating new technologies and products that address critical industry needs.

One such pairing saw that Looq was partnering with Central Hudson Gas & Electric in July 2024 to rapidly capture, create and analyze a large, representative data set of distribution poles, lines and substations. This project included the following:

- Models of 2500 poles and 5 substations
- 3D point clouds
- Panoramas
- Ortho-images (nadir view)
- Segmentations of lines, poles, vegetation, ground and other features
- Extraction of line-pole geometry for loading analysis

Chris Gilbert, manager of R&D and Innovation, at Central Hudson Gas and Electric, says, "While we are only at the capture stage of this project, ultimately where we would like to be is delivering greater resilience in the grid – where customer interruptions from our overhead system due to equipment faults and vegetation impacts are rare and quickly addressed."

Large-scale data capture and automated 3D intelligent model creation are now easily in reach for electric utilities seeking to improve documentation of their distribution and substation assets. Improved segmentation, classification and defect detection are key to creating additional value for maintenance and vegetation management applications. Todd Hylton, VP Strategy, Looq AI says, "Working with the team at Central Hudson, Looq was able to understand their pressing needs in defect detection and vegetation management in addition to the data capture and geometric analyses that were the focus of the project. Our work together continues as we develop these new capabilities in pursuit of a more reliable and more affordable grid."

The utility and Looq have agreed to continue working together to develop these capabilities, which will leverage the data collected and the learnings derived from this project. Gilbert concludes, "With enhanced access to accurate, up-to-date data, we would be able to more proactively manage potential risks, optimize maintenance and bolster system reliability. This approach builds on our existing strengths to deliver an even higher standard of dependable service that our customers can continue to count on." →

> **The benefits of this improved process include optimized resources, lower costs and improved safety.**

Testing AI-enabled asset capture at Aquawolf

With this new process, Aquawolf is proving they can capture, analyze, deliver reliable, high-quality digital twins and help their clients transform their approach to both small and large-scale photogrammetry. Aquawolf, a wholly owned subsidiary of Mammoth Energy Partners LLC, manages multiple types and aspects of projects including preliminary electric transmission and distribution line routing; natural gas pipeline conceptual design; detailed transmission and distribution line design, pipeline design and construction support. Many of the projects they manage are resource and time-intensive and often require working with 3D data.

Aquawolf is testing and implementing an innovative approach to supplement traditional surveys that is one-third the cost. Historically with projects like these, Aquawolf would send out crews to walk every mile of a site and simultaneously they would send crews to capture an entire area – often 50-60% more data than was necessary. Traditional processes might include drones or fixed-wing planes; they would take photographs, process topographic maps and transcribe all the features. This could include billions of points of data meaning they would need to narrow to what was needed for the project using civil engineering tools for thinning the data.

With their new workflow using a novel AI-enabled camera technology, they have a survey grade point cloud from which to work that has replaced an aerial flight, the scribing process and most of the topographic processing. This is all due to the back-end AI process. The team can walk around and capture while they evaluate the site. Everything that humans see the camera can see as well. This new capture process eliminates the need for data to be collected by both surveyors and field technicians and can minimize the use of civil tools for thinning the data. "Survey firms will bid on an entire package. We no longer need to do this," says Alex Richards, PE, President, Aquawolf. "Instead, we walk every mile of an overhead project with Looq AI's hand-held camera. We are developing the digital twin while on-site and in one trip as opposed to multiple. There is no need to re-field because we get everything necessary in a single visit."

On one project the Aquawolf team was working with rough terrain dense with vegetation, the alignments were in the trees. The original survey had gaps in both topography and features because they were both obscured. "With boots on the ground, we got into locations the survey could not. We got under the tree covers and could see through all the obstacles," says Blake Darling, PE, PMP, director of Engineering Underground Programs, Aquawolf. "Filling these gaps surgically means we deliver a better product, with 30% in cost savings in the amount of data that needs to be processed. This has been a key component of helping Aquawolf maintain its reputation for agility and high-quality engineering and design." This new workflow has helped Aquawolf spend their time on more valuable work. Rather than spending considerable time aggregating terabytes of unnecessary data, they are enabling key decision-makers and engineers. This approach means fewer truck rolls and fewer crews engaging with energized assets, working in rough terrain or dodging vehicle traffic. The benefits of this improved process include optimized resources, lower costs and improved safety.

Aquawolf is providing engineering and design services on a large western utility for a 10-year program to underground all high-risk electric distribution circuits in the backcountry where there are high wind, fire and other threats to the overhead equipment. Due to the program's scale, the utility sent surveys to collect data way before the design. However, the survey did not cover 100% of the area needed.

Aquawolf decided to implement their new capture workflow allowing them to capture rich data easily and rapidly beyond what they would normally get from traditional land surveys. Because it is so easy to capture the site, Aquawolf was able to collect a significant amount of data without needing to know exactly which data points would be relevant once they began designing. In a traditional process, they would have figured out first what they needed and requested specific survey requests requiring detailed explanations to the surveyor. Often there is a great deal of back-and-forth communication happening because someone forgets specific features

or needs to expand the survey area – all of this can be time-consuming and expensive. "We capture everything we see while walking the site and all of that becomes the digital twin," says Darling. "Even the first couple of times we used the technology, we had this intuition that we were approaching survey accuracy and could supplement the traditional survey process at one-third the cost of traditional land survey." Aquawolf can ask a survey to establish a control network, then they verify the points in their scan to match what the surveyors found tightening up the accuracy – and all of this is at a fraction of the original cost.

When the captured data hits the cloud, there is an advanced algorithm working to craft a high-precision, geo-referenced 3D digital twin and 2D images that can be used to perform asset analysis. "The real magic is the AI-enabled software. We can automate 3D modeling and seamlessly interact with digital twins enhancing the collaboration with our client and helping to streamline their decisions," says Richards. "This all happens in a dashboard where everyone can view, analyze, track, hand off the project." Working more collaboratively with utility clients is much simpler because everyone can view, interact and collaborate on survey-grade 3D models within the data portal.

Through proving this new workflow in their overhead projects, Aquawolf sees opportunities to improve planning and design projects as well as value-added services that can supplement utilities' inspection and maintenance.

Utility overhead distribution upgrades – These projects are smaller in scale such as a highway crossing or road widening requiring updates only to a few spans. Typically, utilities do not want to wait or pay for traditional LiDAR because they do not need the entire line point to point. Aquawolf will collect the required area much faster and create an accurate 3D model from that data which can be quickly incorporated into more powerful modeling software providing an accurate representation of current conditions.

Joint-use - When communications companies want fiber optic attachments to utility poles, they must take measurements and provide this information in their request. Using this new workflow, the team at Aquawolf can quickly capture and deliver the necessary data including measurements and proof of clearance. When needed, they can provide a 3D model to support simulation and analysis such as pole loading.

Overhead transmission design and documentation - Aquawolf can provide supplemental data for overhead transmission design by capturing wires and structures for modeling. Their new process allows for rapid capture of specific poles or spans, seamlessly integrating these into existing LiDAR datasets, thus expediting data updates for utilities. Traditionally, requesting a LiDAR vendor go back and collect this could delay data updates by several months.

Many lattice towers have been operational for more than 60 years and through these years of inspection and maintenance, most have undocumented replacement parts. Aquawolf can utilize this new workflow to get a quick scan of each tower during project visits allowing them to provide immediate documentation to the utility. This could include a more accurate record of the tower and any damage, bolt counts and other structural assessments. By leveraging this new approach, these scans are processed swiftly for use with engineering analysis applications. This ensures that current tower conditions are accurately reflected in the engineering models.

Collaboration for the benefit of many

Through more collaborative partnerships, surveying and engineering firms can create a continuous cycle of innovation and application helping them to stay at the forefront of industry advancement and offer more sophisticated and economical solutions to their clients. Amanda Jones, CEO of AJ Surveying, "The use of this technology is a game-changer for us. It gives us the opportunity to capture a large amount of survey-grade data."

Kevin Grover, advanced technology leader at McElhanney Ltd says, "I haven't been this excited about a new 3D capture technology in a long time. The speed and quality of the survey data are paramount to other 3D technology on the market today. We are excited to be an early partner."

Darling concludes, "The platform has become an indispensable engineering tool in our fielding tool kit. Their unique hardware and groundbreaking back-end processing have enabled our design teams to capture highly detailed and accurate field conditions in the absence of existing survey data. During all phases of design, we have been able to fill holes in our existing survey base maps quickly and reliably with rich data which keeps design moving forward while we wait for traditional land survey." →

The objective of the early adopters is to help them align the hardware and software evolution to the needs of their clients and the services and value they want to deliver. Such strategic collaborations not only foster technological advancement but also strengthen the relationships among the parties involved, creating an ecosystem focused on innovation and operational excellence. Richards concludes, "While the qCAM is a simple piece of hardware, the software has almost limitless possibilities for the future. The team has been receptive and innovative in the types of data tools they deploy regularly – automation of point processing, point cloud classifications and the ability to manipulate this inside the user interface. We continue to have conversations about the next improvements."

The growth of the relationships between utilities and their research and supplier ecosystem is evidence that such alliances can form a better framework for advancing grid modernization efforts. Sara Chilcott, Grants Coordinator /2024 IEL Project Manager says "Our partnership with Looq AI has been a collaborative journey, providing invaluable learnings for both sides. Looq's openness to feedback has been instrumental in refining their technology to align with our specific needs and improving our workflows. Their commitment to innovation and responsiveness has strengthened our ability to take meaningful steps toward achieving our ideal state of a more resilient grid. As we continue this project, we're excited to not only advance our own goals but also share these lessons learned to help other utilities implement similar solutions, driving progress across the industry."

These collaborations create the necessary environment for rapid development and implementation of technologies that are not only effective but also adaptable to the changing landscape of global energy.

ABOUT THE AUTHOR:

Teresa Elliott is the vice president of marketing Looq AI, bringing more than 20 years of experience in B2B software and services marketing in AECO/Infrastructure. Elliott has worked with innovative desktop, cloud technology, SaaS/PaaS and photogrammetric solutions from Autodesk, Bentley Systems, Intergraph and others.

She has authored articles and delivered professional design hours for water, cities and energy verticals. She earned her Executive MBA at Auburn University and a BS in accounting at the University of Alabama in Huntsville. Elliott recently completed certificates in AI Applications for Growth at Northwestern University's Kellogg School of Business and Design Thinking at Stanford University.

NAVIGATING M&A INTEGRATION

IN THE EVOLVING UTILITIES SECTOR

VANESSA AKHTAR

M&A transactions have seen an uptick in the energy and utilities industry amid cost pressures, changing government regulations and the energy transition. As of 2024, the value of announced deals in the industry exceeded $150 billion, nearly double the value through the same period in 2023. M&A is expected to further accelerate in Q1 2025 after the Fed's anticipated rate cut.

While there is significant opportunity in the sector to enable more reliable, affordable and sustainable energy solutions through M&A transactions, there is also significant risk. Most M&A activity fails to see the expected value of the transaction because ineffective integration processes and inadequate cultural integration prevent its full realization. Utility leaders need to think differently about how they approach these corporate reorganizations for their own bottom lines and to ensure they can continue to deliver safe and affordable energy to their customers. This requires adopting key strategies before, during and after the deal that prioritize a clear vision of the future and communication, active engagement and buy-in between all parties involved.

Setting M&A deals up for success

Smooth leadership and team transitions should start weeks to months before a deal closes and continue well after.

Pre-deal closing

It's important to *consistently and clearly articulate the value* that each legacy business brings to the transaction – and the anticipated plan for how to optimize that value. For example, are you looking for a true integration or will you continue to run separate operations under a common "holding" company? This requires aligning the opportunities a transaction presents to both organizations as early as possible. Is it about expanding service territory? Enabling faster innovation and adoption of renewable energy solutions? Furthermore, before the transaction, be very diligent about conducting a culture audit and understanding the value of each of the legacy businesses. This will require an assessment of where there may be natural alignment or potential tension points. Then, use this information when evaluating the potential of the deal and whether it will yield the value you're seeking. Once the ideal outcomes are defined, they can be used as a guidepost for designing the leadership and team structures needed to optimize the opportunity at hand. →

Too often, M&A leads to restructuring efforts that are grounded in old ways of thinking or a "winner takes it all" type of mindset. Instead, think about what structures will best enable value realization. Consider what should be centralized and what functions should or need to remain decentralized for the business to remain effective. Assess the strengths of each of the legacy businesses – and how these do or do not, align with the future state structure. Do this before determining who will lead which functions, business units and teams, to avoid the pitfall of building teams around a specific leader without consideration for what structure is most likely to achieve the best business outcomes.

As you start to determine which executives will take which roles, clearly articulate the skills, mindsets and ways of working that are going to be needed to recognize the expected value of the newly integrated organization. It's important to recognize that what is needed for the future state may be different than what was needed in each legacy business. In addition, think through which functions and teams *need* to work in concert to achieve target outcomes (like Shared Services or Operations if you are looking to drive enhanced cost efficiency) and which may have the biggest impact in demonstrating an integrated and collaborative culture between both legacy entities. Which business lines or functional units you emphasize will likely depend on the ultimate structure of the business, such as a regional setup versus a service line setup (electric, gas, transmission, etc.).

Post-close

After the deal closes, carefully execute the plan in place and be intentional. If the acquired company will be integrated versus kept separate as an investment, communicate any new expectations of employees well before any changes take effect and encourage everyone to collaborate on identifying where they can work together in new ways. This, of course, includes any changes to integrated technology systems, employee benefits and compensation packages, etc. But, even more importantly, leaders need to emphasize and reinforce how work gets done.

Have teams at all levels be part of the transition by enlisting them to help shape how end-to-end processes will work in the new organization, including what handoffs, roles and success look like. This will foster a better understanding of what they are trying to achieve together and why – and will help create a sense of ownership in the future state. Regular internal communication to keep employees engaged and feel included in the process is key to generating buy-in. Sharing the value of the deal and why employees should care is also vital and must go beyond just increased revenue. As employees contribute to a (hopefully) seamless integration, be sure to highlight these contributions and how they are helping to drive value.

Setting employees and executives up for success

M&A transactions come with some amount of unavoidable uncertainty and risk, which is likely to trigger employees' "Survive" reactions. Many employees are likely to view M&A as a potential threat – to their role, stability and comfort – that will create a sense of anxiety and potential trepidation. While this reaction can be useful to a degree because it creates a sense of laser-focused problem-solving, it can also get in the way of effective integration if not managed well. To ensure this Survive response doesn't "overheat," creating a pervasive resistance to the change, leaders need to also find ways to activate "Thrive" by helping the workforce see the opportunities ahead – not just for the business, but for themselves as individuals.

Too often during M&A, there's a sense of, "This is just part of the process that we need to accept," but that doesn't need to be the case. Leaders can get ahead of any negative responses to the perceived threat of M&A and instead foster excitement for a new chapter by:

- **Communicating** the opportunity this transaction creates for customers, employees and the business. And don't just say it once. Articulate the opportunity over and over again, in different forums and using different delivery mechanisms.
- **Acknowledging** the reality that people are likely feeling uncertain and anxious. This will help mitigate the perception that leaders' optimism is naïve or out-of-touch with front-line employees. Provide opportunities for people to share how they are feeling, and why, so there is a healthy outlet for concerns.
- **Being clear** about what leaders do and do not know. This is more helpful than waiting to address questions because it will prevent employees from assuming leaders have answers they aren't sharing. Leaders also need to be open and honest throughout to maintain morale and momentum.
- **Engaging** teams with hands-on work as soon as you can to create a sense of ownership and belonging. For example, train call center reps to receive calls from the other company's customers by collaborating on scripts and drafting question responses.

As B.R., the EVP of Strategic Transformation Projects at a large U.S. utility, adeptly articulated, people are *the* key to any successful transaction:

> *M&A transactions meet or exceed their objectives because of the people. Once the deal is announced, moving quickly towards engaging the people, from both companies, to accelerate from survive to thrive is vital. The approval process for a utility transaction is usually protracted due to the additional regulatory approvals required. Use this time to accelerate the engagement of the team from senior leaders down to frame up how the new organization will operate, including the values of the combined entity, compensation and benefits and other areas that accelerate the survive to thrive focus post-closing.*

Empowering teams to be part of the solution keeps them engaged and feeling valued as part of the company's future. No one wants change done to them – employees are much more likely to help drive value if the change is done *with* them. →

Setting the sector up for success

Every single utility is committed to providing reliable, safe and affordable energy to its customers – and many are increasing their focus on a commitment to sustainable energy solutions. The fact that these are consistent across utility companies could actually create some risks when it comes to M&A. Beneath the layer of shared language, utilities can exhibit vastly different cultures and approaches to achieving these commitments to their customers. For example, across the sector, there are wildly varying levels of risk aversion versus risk-taking.

This dichotomy is especially critical when it comes to the industry's race to net-zero goals or the deployment of emerging technologies like AI. Some utilities may eagerly position themselves as pioneers, willing to blaze a trail and embrace innovation, while others opt to cautiously wait and follow established best practices. Moreover, because the industry has a traditionally long-tenured workforce, the established cultural norms in each organization have very deep roots that are hard to change.

In addition, aligning the workforce's capabilities with the evolving needs of the business may require a cultural shift in how utilities approach talent management. Traditionally, utilities, employees are valued for their deep technical expertise in a given area. When bringing two entities together, with a focus on meeting the *future* needs of the industry, leaders will likely need to upskill or reskill employees. Balancing the needs of today (like replacing aging infrastructure) with the demands of tomorrow (like increased load growth and the clean energy transition), requires an agile workforce with skills that are transferable across teams and roles.

Ultimately, successful M&A comes down to being crystal clear on the organizational behaviors that will achieve long-term success in the rapidly evolving energy sector. When an industry is undergoing profound change, or a utility is working through a merger or acquisition, bringing the new organization along requires thoughtful approaches and a united strategic vision. Rather than dwelling on "how we used to do things," keep messaging and initiatives resolutely forward-looking and results-oriented. Maintaining a sharp focus on what will equip the company to thrive in the future will help hold everyone accountable for measurable success. This will require building and maintaining trust by respectfully challenging teams, continually clarifying expected behaviors and mindsets and co-creating examples of what success looks like in the new context.

For utilities in particular, maintaining operational efficiency is paramount. Being deliberate about reducing handoffs, increasing innovation and enabling human capital to work in tandem with technology can make a significant difference in day-to-day performance. Given the industry's large population of long-tenured employees, loyalty and personal connections should be appropriately honored during integration. Prioritizing clear communication and expectations about the path ahead will be essential for managing the natural anxiety that accompanies the major changes that come with M&A.

ABOUT THE AUTHOR:

Vanessa Akhtar is managing director and head of consulting at change management and strategy execution firm Kotter. She is also the co-author of "Change: How Organizations Achieve Hard-to-Imagine Results in Uncertain and Volatile Times."

AI WORKLOADS AND HA CLUSTERING

A CORNERSTONE OF MODERN ENERGY SYSTEMS

DON BOXLEY

Artificial intelligence (AI) is becoming integral across virtually every industry – including modern energy systems, driving increased innovation and operational efficiency. So, whether you are an electric utility or an independent power producer – likewise, a major power-consuming industry – AI is revolutionizing how energy is generated, distributed and consumed. However, for AI to deliver on its promise, one critical component is essential – high availability (HA). *i.e.*, a system or solution designed to ensure continuous operational performance and minimal downtime, even in the event of hardware or software failure. Without a solid HA solution ensuring continuous uptime, reliable performance and system stability, your AI apps can fall short.

Better yet, with HA clustering, energy organizations have the robust foundation needed to maintain seamless operations, optimize resource management and meet the evolving demands of the energy sector.

Keeping AI running smoothly with HA clustering

Whether it's optimizing grid performance, predicting equipment maintenance, or supporting real-time decision-making, AI is becoming an indispensable tool across the industry. However, as the reliance on AI continues to grow, there comes an equally growing demand for IT systems that can handle the load – every second of every day.

Of course, like any innovative technology solution – for AI to do its job, you need to provide it with a rock-solid foundation. Yes, you guessed it – that's where HA clustering comes in. HA clustering is the configuration of multiple servers working together to minimize downtime and ensure continuous application or service availability by automatically transferring workloads to another server in the cluster during failures. In other words – a safety net through failover and redundancy. No downtime, no interruptions. Ever. And, as energy organizations deploy more advanced AI models to tackle increasingly complex challenges, this kind of built-in resilience will become a deal-breaker. →

Keeping AI resilient across clouds

AI applications often operate across mixed infrastructure and multi-cloud environments. In other words, they pull data and insights from systems that might be on-prem, in the cloud, or both. This is a powerful setup for energy organizations managing complex operations – but of course, it also comes with a challenge: how do you ensure these critical AI systems are always up and running, no matter where they're hosted?

This is exactly where infrastructure-agnostic HA clustering steps in. If one system fails, it ensures that another takes over instantly – keeping your AI workloads running, without a hitch. This means that with HA clustering, energy companies can focus on scaling their AI initiatives – such as using machine learning (ML) to predict equipment failures or optimize energy distribution – without worrying about downtime or delays.

Take, for example, a utility company using AI to predict peak energy demand during extreme weather. This system relies on real-time data from multiple sources, stored both on-premises and in the cloud. With HA clustering in place, if one server or cloud region goes offline, the workload automatically shifts to a backup, ensuring the AI model continues delivering accurate forecasts to prevent grid overloads or outages.

"As energy companies increasingly move to cross-platform data estates, ensuring AI stays resilient is key," I often tell clients. "With the right HA clustering, you can keep everything running smoothly – no matter where your data lives or how unpredictable the environment gets."

Keeping AI environments secure

AI systems are all about dealing with massive amounts of data and keeping really complex systems up and running – but with all that data and connectivity, there's a huge responsibility: security. Protecting these systems isn't just about slapping on firewalls or using fancy monitoring tools; it's about baking resilience right into the infrastructure itself.

That's where HA clustering comes in. Sure, it's famous for keeping systems running no matter what, but it's also got your back when it comes to protecting critical AI operations. For example, imagine one part of your system gets hit – HA clustering can automatically shift workloads to unaffected nodes, cutting down exposure and keeping things moving without skipping a beat.

For energy companies that are using AI to manage power grids, this kind of protection is a game-changer. If a cyberattack hits one part of the system, "smart" HA clustering can lock down the problem area while still letting AI models do their thing – whether that's predicting energy demand or spotting outages.

The bottom line? A secure, reliable setup where AI can just do its thing without worrying about interruptions – letting you focus on innovation, not chaos.

Building a resilient AI future

AI is changing the game for how companies work, innovate and stay competitive. But let's be real – AI can't work its magic on just fancy algorithms and tons of data. It needs a strong, reliable foundation to actually deliver. That's where HA clustering steps in – it's like the safety net that keeps IT environments running strong.

For energy companies, HA clustering makes sure AI systems stay up and running, no matter what. Think real-time energy demand, predictive equipment maintenance, or adding renewable energy sources into the mix – HA clustering keeps things running smoothly without any hiccups.

The bottom line for IT leaders? Your AI is only as dependable as the HA setup behind it. Building a rock-solid, always-on infrastructure isn't just a nice-to-have; it's the backbone of every successful AI project. Make sure your systems are ready for what's next.

Steps for implementing HA clustering

1. Assess Current IT Infrastructure
   - Conduct an audit of existing systems to identify potential vulnerabilities, downtime risks and performance bottlenecks
2. Define AI Workload Requirements
   - Identify the AI applications critical to your operations (*e.g.*, grid optimization, equipment maintenance, demand forecasting)
   - Assess the data sources, storage and compute power these workloads require
3. Select the Right HA Clustering Solution
   - Research and compare HA clustering software and tools, ensuring they align with your operational needs and budget
   - Prioritize solutions that support cross-platform data estates for flexibility and scalability
4. Integrate HA Clustering with Cloud Platforms
   - Work with cloud service providers to implement a unified HA clustering solution across your full cloud environment
   - Ensure that failover mechanisms and redundancy are configured correctly for seamless operation
5. Build Security into the Infrastructure
   - Incorporate security protocols, such as encrypted communication and intrusion detection, within the HA cluster.
   - Plan for DR by automating backups and enabling quick data restoration
6. Test for Resilience and Performance
   - Simulate failover scenarios to ensure the cluster performs as expected during disruptions
   - Monitor latency, recovery time and overall system performance under different workloads
7. Train IT Staff and Create Support Plans
   - Train your IT team to manage, troubleshoot and optimize the HA clustering setup
   - Establish a support plan, including monitoring tools and escalation paths, to address issues promptly
8. Continuously Monitor and Optimize
   - Use performance analytics to track uptime, workload distribution and potential bottlenecks
   - Regularly update and scale the cluster to meet evolving AI demands and infrastructure changes

ABOUT THE AUTHOR:

Don Boxley Jr is a DH2i Co-founder and CEO. He has more than 20 years in management positions for leading technology companies. Boxley earned his MBA from the Johnson School of Management, Cornell University.

FUTURE-PROOFING

FOR THE GRID OF TOMORROW

RON PATE

As the power grid evolves to meet increasing demands and environmental challenges, professionals in the electrical engineering and energy sectors must take a proactive approach to ensure reliability and resiliency. The growing frequency of extreme weather events, aging infrastructure and rising energy consumption require a strategic shift toward automation and predictive technologies. The key question for utilities is: How can they invest in the future while minimizing costs today? The answer lies in future-proofing – choosing solutions that allow for seamless integration of advanced technologies over time.

As utilities plan for the future, they must navigate an evolving landscape of grid modernization challenges and opportunities. This article will explore key strategies and technologies that can help utilities build a more resilient, efficient and intelligent power grid. From automation and predictive analytics to advanced equipment integration and artificial intelligence (AI), we will examine how utilities can make strategic investments today to ensure long-term success tomorrow.

Reliability vs. resiliency: A shifting focus

The conversation around grid modernization is evolving from focusing on reliability to a broader discussion on resiliency. Traditionally, reliability has been about minimizing downtime and restoring power quickly after outages caused by common events such as animal interference or falling tree branches. Resiliency, however, goes further – it ensures that the grid can dynamically adapt and recover from large-scale disruptions such as natural disasters or cyberattacks. This shift is crucial as climate change and increasing grid complexities demand more robust and intelligent solutions.

The impact of climate change on grid resiliency

Extreme weather events are occurring with greater frequency and intensity, creating significant challenges for utilities. Recent data underscores the escalating frequency and intensity of extreme weather events. According to Climate Central, 80% of major U.S. power outages between 2000 and 2023 were weather-related, with severe weather events accounting for 58%, winter storms 23% and tropical cyclones including hurricanes 14%. With such events causing widespread power outages, utilities must invest in technologies that enhance resiliency. In wildfire-prone areas, for instance, utilities are implementing grid automation solutions that allow for remote de-energization of power lines when fire risks are high. Similarly, flood-resistant substations and elevated infrastructure designs are being deployed to mitigate storm-related damage. →

Moreover, temperature fluctuations affect energy consumption patterns. Utilities must ensure that their grids can handle peak loads during extreme heat waves or cold snaps. The integration of smart technologies enables predictive load management, preventing grid overload and ensuring a consistent power supply even in adverse conditions.

Investing in future-ready automation

Automation plays a pivotal role in achieving both reliability and resiliency. Advanced reclosers and other intelligent switching devices allow utilities to reroute power dynamically, mitigating the impact of faults. Reclosers, which historically focused on clearing temporary faults, now serve as essential components of self-healing grids, working with sensors and automation systems to minimize downtime and optimize power distribution.

A key aspect of automation is the ability to reconfigure the grid remotely. Utilities can now use reclosers not only for fault isolation but also as automated switching devices that intelligently reroute power, reducing outage impact and improving response time. This automation also enables real-time adjustments in response to extreme weather conditions, minimizing the risk of secondary failures.

Reducing operational costs with automated solutions

Grid automation significantly reduces the need for manual intervention, leading to lower operational costs. By using automated solutions, utilities can quickly isolate and restore service without dispatching field crews. This is particularly beneficial in rural areas, where travel times for maintenance personnel can be extensive. Automation also enhances workforce efficiency, allowing skilled personnel to focus on more complex grid management tasks instead of routine fault clearing.

Integrating advanced equipment for future-proofing

Modern grid infrastructure relies on intelligent, multifunctional equipment that enhances automation, reduces maintenance needs and improves overall efficiency. For example, some advanced reclosers integrate sensing, switching and metering capabilities into a single unit, allowing utilities to collect real-time grid data to assist with energy measurement and power quality analysis, while also providing for fault protection and grid automation. These devices are designed to be adaptable, ensuring compatibility with future automation and predictive analytics technologies.

Bundling technologies for greater flexibility

Let's expand further on the benefits of integration. Rather than deploying disparate technologies for switching, sensing and metering, utilities can achieve better efficiency and cost savings by integrating these functions into a single solution. Combining sensing and switching, for example, allows for real-time fault detection with greater real-time edge intelligence, enabling better immediate corrective action. Similarly, integrated sensing with metering enhances energy measurement with revenue grade accuracy while providing utilities with valuable power quality insights.

This bundled "platform" approach minimizes installation complexity and operational costs while laying the foundation for future enhancements. With utilities facing resource constraints, including workforce shortages, simplifying deployments through multi-functional equipment is a critical strategy. Bundling technologies together into one integrated, more flexible solution also provides more – and better – data down the road.

The role of data in grid modernization

Data is the backbone of a modernized grid, driving efficiency, reliability and resilience. The integration of high-resolution data collection from sensors, smart meters and IoT-enabled devices enables utilities to gain real-time visibility into grid performance. By analyzing consumption patterns and detecting anomalies, utilities can respond proactively to fluctuations in demand and foreseeable outages.

Advanced data analytics play a crucial role in optimizing grid operations by identifying stress points. Additionally, the ability to harness accurate, real-time data enhances regulatory compliance by ensuring adherence to evolving energy policies and safety standards.

Beyond operational improvements, data-driven insights support long-term strategic planning, enabling utilities to anticipate future energy demands, integrate renewable energy sources more effectively and modernize aging infrastructure. →

The evolution of predictive analytics, AI and advanced sensing

Predictive analytics is set to revolutionize grid management by enabling real-time diagnostics and anticipating potential disruptions. Self-monitoring using sensors embedded in recloser solutions and switches can report grid status and anomalies, signaling maintenance needs and allowing utilities to shift from a reactive to a proactive maintenance model. This transition reduces operational costs, extends equipment life and minimizes unplanned outages.

AI further enhances predictive analytics by processing vast volumes of grid data to optimize performance. AI-powered systems can anticipate demand fluctuations, detect fault patterns and recommend automated reconfiguration strategies. With AI-driven diagnostics, utilities can achieve unprecedented levels of efficiency and reliability.

Advanced sensor technologies allow advanced grid state analysis. Detection of signatures of grid issues offers a more accurate location of issues in the grid, including but not limited to more accurate fault locations. Advanced sensor technologies further enhance capabilities by enabling high-precision monitoring of voltage fluctuations, power quality and equipment health. By integrating these advanced sensors, utilities can proactively pinpoint potential failures and implement preventive measures, reducing the risk of costly grid equipment damage and outages.

Future-proofing in action: A case study

While AI-driven decision-making and more advanced sensing technologies are shaping the future of grid management, many utilities are already taking critical steps to enhance reliability and automation using currently available technologies. One such example is a utility that sought to modernize its aging transmission infrastructure to improve operational efficiency and reduce outage times.

Based in the Northeastern U.S., this utility serves over 3.5 million customers across multiple service areas which are mostly rural, with more than 1,000 miles of transmission line right-of-way. The utility recently faced the need to modernize its 69kV transmission network while enhancing automation and reliability. The existing infrastructure relied on outdated air-insulated load break switches that lacked fault interruption capabilities, requiring manual fault location and service restoration, which led to prolonged outages.

To address these challenges, the utility deployed a recloser rated up to 70kV designed to provide automation capabilities, sectionalize transmission lines and enhance grid flexibility. By strategically placing reclosers every few miles along the transmission network, the utility was able to minimize the impact of faults – therefore significantly reducing the number of customers affected by outages and improving service restoration times.

In summary, the utility realized multiple benefits including:

- **Automated Fault Isolation and Restoration:** The newly installed reclosers allowed for rapid fault detection and response, significantly reducing outage durations.
- **Enhanced Remote Monitoring and Control:** Integrated sensors provided real-time data on system performance, enabling proactive maintenance and reducing the need for manual inspections.
- **Reduced Maintenance Requirements:** The use of solid dielectric insulation eliminated the need for oil, SF6 gas and the routine maintenance needed on traditional air insulated switches, thus improving environmental sustainability and lowering operational costs.
- **Flexible Grid Expansion:** The ability to sectionalize transmission lines without requiring new switching substation infrastructure helped the utility expand capacity efficiently.
- **Operator and Environmental Safety:** By encapsulating key components in dielectric insulation, the reclosers minimized exposure to harsh weather and improved overall system reliability.

This successful implementation underscores how future-proofing the grid with advanced automation-ready solutions can help utilities modernize their infrastructure without excessive investment in new substations or extensive manual interventions.

Future trends in grid modernization

What lies ahead? The energy sector is undergoing a rapid transformation driven by advances in automation, artificial intelligence and distributed energy resources. As utilities look to modernize their infrastructure, several emerging trends are shaping the future of grid management.

These innovations will enhance reliability, resiliency and operational efficiency while addressing evolving challenges such as climate change, cybersecurity threats and increasing demand for renewable energy integration. They include:

- **Self-Diagnosing Equipment:** As AI and sensors become more advanced, reclosers and other switching devices will feature more self-monitoring capabilities, alerting utilities when maintenance is required.

- **Fully Automated Self-Healing Grids:** Future grids will have ever-increasing built-in intelligence to automatically reroute power in the event of an outage, minimizing disruption and eliminating the need for manual intervention.
- **Decentralized Power Management:** As more distributed energy resources (DERs) such as solar and wind are integrated into the grid, power quality analysis, automation and AI will play a crucial role in managing the grid and balancing energy distribution efficiently.
- **Cybersecurity in Automation:** As automation increases, so does the need for robust cybersecurity measures to prevent threats from bad actors targeting grid infrastructure.

The path forward

As utilities navigate the evolving energy landscape, investing in the right equipment now is no longer optional – it's essential. By adopting automation-ready solutions, integrating technologies for greater flexibility and leveraging predictive analytics, utilities can enhance grid reliability and resiliency while optimizing costs. AI and more advanced sensing options will further refine grid management, setting the stage for a smarter, self-healing network.

The power grid of tomorrow is being built today. The utilities that prioritize future-proofing will not only stay ahead of industry challenges but will also deliver safer, more reliable power to their customers for decades to come.

Key considerations when investing in grid equipment

Selecting the right equipment is crucial for utilities aiming to modernize their infrastructure while maintaining reliability and cost efficiency. As the grid evolves, they must evaluate new technologies based on their adaptability, longevity and ability to integrate with automation and analytics. The following key considerations can help ensure that grid investments support long-term operational goals and resiliency.

- **Automation Readiness:** Ensuring new equipment can support future grid automation strategies, including remote fault detection and power rerouting.
- **Design Flexibility:** Deploying modular configurations that adapt to different grid layouts and operational requirements.
- **Reduced Maintenance Needs:** Utilizing solid dielectric insulation materials to minimize maintenance and extend operational lifespan.
- **Enhanced Data Collection:** Incorporating high-accuracy sensors to improve real-time monitoring and analytics.
- **Operational Efficiency:** Reducing installation complexity and ensuring ease of integration with existing grid management systems.

ABOUT THE AUTHOR:

Ron Pate leads the global product line management for G&W Electric's overhead technologies portfolio. He is active within numerous IEEE groups and also chairs the IEEE PSIM Sensors Subcommittee, which is focused on next-generation current, voltage and related sensing technology for the evolving energy grid. Pate has 34 years of experience in the power industry and is a recognized thought leader and industry expert, especially in the application of technology solutions for improved monitoring and management of the grid.

ELECTRICITY AND INFRASTRUCTURE:

THE MISSING ELEMENTS OF THE ELECTRIFICATION PUSH

You will soon reach the energy limit to which you are entitled.

NOTICE

JONATHAN LESSER, PH.D.

The Trump Administration is eliminating some federal rules to force electrification, including new vehicle mileage standards issued by the Environmental Protection Agency last year that could only be met by automakers through increased production and sale of EVs. More rules, such as those to "encourage" consumers to install electric heat pumps by banning all but the costliest condensing natural gas furnaces, are likely to be dropped as well. But many states continue their headlong rush to force individuals and businesses to replace fossil fuel-using equipment – cars, trucks, boilers and, yes, even gas stoves – with electric versions.

The eagerness to accelerate electrification is driven by aspirations to reduce greenhouse gas emissions. However, policymakers' singular focus on reducing GHGs for electric utility planning efforts, which will have no measurable impacts on world climate, ignores economic and environmental realities. →

Regardless of one's beliefs on the importance of electrification mandates, all share what should be an uncontroversial trait: they require sufficient supplies of power and the supporting infrastructure to deliver it (transmission lines, transformers, neighborhood poles and wires, etc.) to ensure that the electricity required will be reliable and affordable.

Yet, at the behest of regulators and politicians, utility companies are increasingly ignoring this reality and instead focusing on policies that emphasize rationing, primarily through higher prices, but also via restrictions on consumers' access to electricity. In other words, rather than designing an electric system to meet customers' requirements, utilities are focused on constraining customers' access to electricity and trying to accommodate growth in demand mainly by using existing electrical power systems.

As with many ill-considered energy-related initiatives, California leads the way. Customers of that state's investor-owned utilities have "smart meters" that measure electricity use in real time. The utilities have instituted time-of-use (TOU) pricing, which charges – *i.e.*, penalizes – consumers with higher rates when electricity demand peaks, in order to encourage consumers to reduce electricity usage.

For example, Southern California Edison charges residential customers 73 cents/kWh between the hours of 5 p.m. and 8 p.m. in the summer months. By contrast, the average residential rate in California in 2023 was 29.5 cents/kWh. San Diego Gas & Electric charges some residential customers $1.16/kWh on "Reduce Your Use Event" days, which the company can declare 18 times per year. Further north, PG&E charges residential customers 56 cents/kWh during the summer between 4 p.m. and 9 p.m. Rationing by price may be economists' preferred strategy to address scarcity, but it ignores a crucial reality that forcing consumers to rely almost entirely on electricity requires it to be available and affordable.

The high TOU prices are especially hard on consumers living in inland counties where summer temperatures routinely exceed 100 degrees. For them, affordable electricity to run an air conditioner is crucial. Moreover, on average, those counties have the state's highest poverty rates. Many residents received electric bills this past summer exceeding $1,000, despite efforts to reduce their air conditioning use. Sweating in the dark hardly seems a desirable outcome of electrification efforts.

> **[…] end punishing electric pricing regimes, end policies that restrict consumers' ability to use electricity […]**

At the same time as all of the above, the overall reliability of electric systems is decreasing, even when major events such as hurricanes or wildfires are excluded. For example, over the last decade, the amount of time California's Pacific Gas & Electric customers have been blacked out has doubled. Despite unaffordable TOU prices for many consumers and decreasing reliability, a dozen states are following California's model for electricity planning; more are being urged to do so.

This is madness. Forcing individuals and businesses to become even more dependent on electricity and then restricting their access to the electricity required reveals an epic failure in utility planning. Despite long-standing requirements that electric utilities, not just in California but in most states, prepare detailed "least-cost" plans that forecast electricity demand 10-20 years into the future and how the utility intends to meet that demand, utilities are now warning of imminent shortages because of rising demand.

While regulators may applaud utility efforts to reduce the need for new infrastructure and new supplies, both are ignoring costs borne by consumers: direct costs that punish consumption; and indirect costs that force consumers to adjust their behavior and which depress economic growth.

With or without electrification mandates, the importance of electricity to a functioning modern society will continue to grow. Politicians, regulators, and electric utilities need to recognize that fact and plan accordingly, rather than imposing ever more punishing rationing schemes.

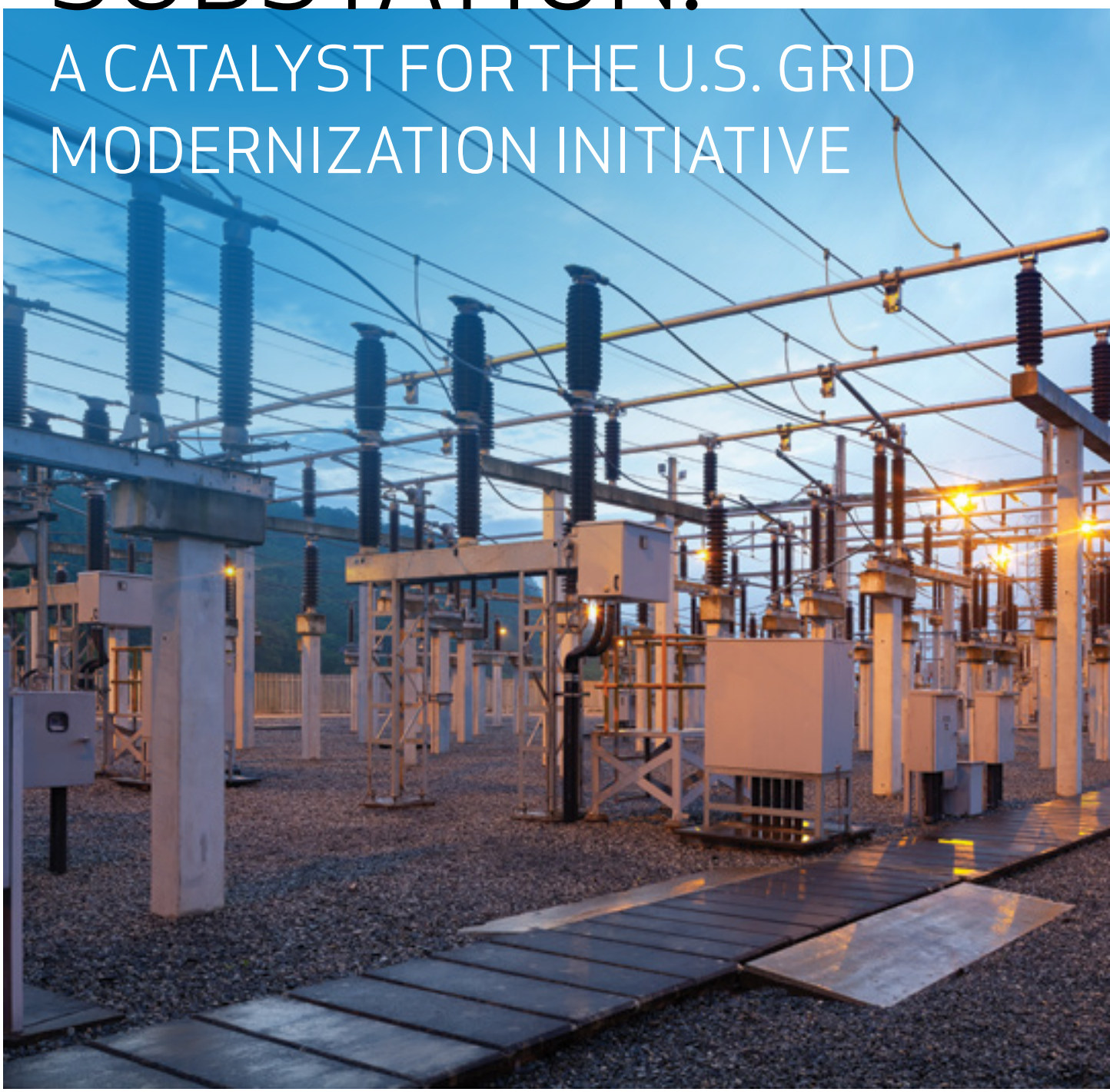
If policymakers want to meet the dual goals of greater electrification and reducing growth in carbon dioxide emissions, the rational policy framework would be to end mandatory electrification efforts; end punishing electric pricing regimes, end policies that restrict consumers' ability to use electricity when they want it and end subsidies and mandates for intermittent wind and solar power, which are destabilizing electric grids. Instead, using natural gas and nuclear power should be emphasized to minimize carbon dioxide emissions, which will do so at a far lower cost and, because they can be sited close to load centers, will require far less investment in new transmission lines to deliver far-flung wind and solar energy.

ABOUT THE AUTHOR:

Jonathan Lesser, Ph.D. is a senior fellow at the National Center for Energy Analytics. His report, "Electrification Without Electricity: An Epic Failure in Planning for Critical Infrastructure," is available at utilities.energyanalytics.org.

THE DIGITAL SUBSTATION:

A CATALYST FOR THE U.S. GRID MODERNIZATION INITIATIVE



STEVE KUNSMAN

The U.S. Department of Energy's (DOE) Grid Modernization Initiative (GMI) represents more than just an update to an aging system. It is a critical and far-reaching strategy designed to reshape the energy landscape, preparing the nation's grid to meet the challenges of a rapidly evolving world. The goals are ambitious – improving grid reliability, integrating renewable energy, supporting EV infrastructure build-up and enhancing security in a landscape increasingly shaped by decentralization and new technologies. Yet, while much attention has been placed on smart grids, battery storage and renewable energy integration – one of the most pivotal elements of this transformation is often overlooked: the substation.

Modernizing the backbone of the grid

Substations, which are essential to managing the flow of electricity across transmission networks, are one of the most antiquated components of the grid. The fact that 70% of U.S. grid equipment is over 25 years old underscores the urgency of modernization. In today's energy environment – where distributed energy resources (DERs) like wind and solar are proliferating – the limitations of these outdated systems become glaring. These substations simply were not designed to accommodate the level of complexity, adaptability in power flow, reliance on information necessary for grid control and responsiveness that the modern grid demands.

This is where the rise of the digital substation becomes paramount. More than just a technological update, digital substations represent a paradigm shift in how we operate and manage the grid. By replacing hardwired systems with intelligent data acquisition, software-driven automation and control, digital substations have the potential to transform grid operations, making them safer, more flexible and more resilient to disruptions. →

Digital substations in grid modernization

At the heart of the DOE's GMI is a clear mandate: to enhance the grid's flexibility and reliability, while also integrating vast amounts of renewable energy. Digital substations are uniquely positioned to achieve these goals. Through advanced data collection and analytics, they provide grid operators with unprecedented visibility into the health and performance of the grid.

One of the key priorities of the GMI is the integration of distributed energy resources (DERs), such as wind, solar and battery storage. As renewable energy sources grow in scale and scope, the grid must be able to adapt dynamically to these intermittent sources. Digital substations are critical enablers in this process, providing the operational flexibility needed to integrate DERs efficiently. By delivering real-time data, these substations allow the grid to adjust in real-time, ensuring a smooth and seamless integration of renewables into the grid, ultimately supporting the nation in reaching its aggressive decarbonization targets.

Information-driven efficiency and resilience

One of the most transformative aspects of digital substations is their ability to leverage data turning it into actionable information. Traditional substations, reliant on manual processes, can take days to identify and rectify issues. In contrast, digital substations can diagnose problems and proactively identify potential issues dramatically reducing downtime and improving reliability. This shift from reactive to proactive grid management supports DOE's GMI strategy key pillar of Resilient and Secure Systems and its goal to reduce outages by 50% over the next decade.

Advanced analytics and artificial intelligence (AI) are key applications enabled by the digital substation. By collecting and processing vast amounts of real-time data, AI can predict equipment failures before they occur, optimize energy flow based on dynamic power flow and provide critical insights into the health of grid assets. In this way, digital substations are not just about modernization – they are about future-proofing the grid and preparing for the demands of tomorrow.

Key benefits of digital substations

For utilities, the business case for digital substations is clear. By transitioning from traditional to digital substations, utilities can realize significant benefits across five key areas:

1. **Reliability:** Real-time monitoring and diagnostics improve asset management and enable predictive maintenance, reducing the risk of failure and the need for costly, unplanned repairs.
2. **Time and Space Savings:** Functional consolidation and digital integration of primary equipment can reduce the physical footprint of a substation control building by 60% and installation and commissioning effort by 40%, resulting in faster deployments and reduced costs.
3. **Safety:** With digital substations, maintenance personnel can perform diagnostics remotely, reducing the need for on-site visits, and the elimination of copper wires greatly reduces the associated safety risks, such as electrical shock and hazardous current transformer secondary open circuits.

4. **Sustainability:** Digital substations are not only about efficiency – they are also about environmental responsibility. By incorporating technologies like SF6-free gas- insulated switchgear (GIS), live tank breakers (LTB) and dead tank breakers (DTB), which eliminate the use of harmful greenhouse gases, digital substations directly contribute to sustainability goals.
5. **Interoperability:** Built on global standards like IEC 61850, digital substations ensure interoperability across manufacturers and future-proof the system for expansion, ensuring a smooth transition to a fully modernized grid.

A path forward for grid modernization

The GMI calls for significant investments – $220 million over the next three years, with 88 projects aimed at enhancing grid resilience, reliability and security. This level of investment reflects the magnitude of the challenge ahead, but it also underscores the opportunity. Digital substations are not just a piece of the puzzle – they are a central element of the strategy, providing the information-driven insights and flexibility needed to build a safe, resilient, reliable and efficient grid.

The GMI also sets an ambitious target: achieving $13 billion in energy savings annually by 2030. Digital substations will play a pivotal role in meeting this goal. By streamlining operations, reducing maintenance costs, and optimizing energy flow, they will help utilities extract more value from existing assets while driving down operational expenses.

Grid modernization's increased digital footprint raises concerns over cybersecurity and supply chain cyber risks. DOE's GMI strategy can leverage the DOE Office of Cybersecurity, Energy Security, and Emergency Response (CESER) recently introduced Supply Chain Cybersecurity Principles for Suppliers and End Users.

Digital substations: The cornerstone of the modern grid

The future of the U.S. grid is information-driven, intelligent and flexible. As the DOE pushes forward with the GMI, the importance of digital substations cannot be overstated. They are key enablers for achieving the initiative's goals – reducing outages, integrating renewable energy and creating a grid that can adapt to the dynamic demands of the 21st century.

As the nation embarks on this journey toward a smarter, more resilient and secure energy future, the digital substation must be seen not merely as a component but as a cornerstone of grid modernization. Now is the time for utilities to embrace this digital transformation to ensure readiness to meet the challenges and opportunities of tomorrow's energy horizon.

ABOUT THE AUTHOR:

Steve Kunsman offers more than 40 years of industry experience and is a recognized substation automation and electric energy operation technology cybersecurity specialist. Since the start of his career in 1984 as an electrical designer for the Brown Boveri Corporation, Kunsman has held various engineering, technology and product management positions within Hitachi Energy's North American and global substation automation organizations.

MODERN POWER SOLUTIONS AND SHIFTING GLOBAL REGULATIONS

EDUARDO DREHMER

The energy market is only getting more complex. “The grid” is actually many power grids that are sometimes haphazardly connected, which makes system-level management harder than it ought to be. Severe weather events are becoming more frequent, testing the vulnerabilities of energy systems and leading to more brownouts and blackouts.

Meanwhile, the industry is dealing with the imperative to go green – to minimize energy waste while shifting away from fossil fuels in favor of renewable sources. There has been much progress with renewables, but the transition has still been fitful. At the same time, global energy demand keeps rising with ongoing industrialization, compounded by the adoption of new power-hungry applications such as electric vehicles (EVs) and artificial intelligence (AI).

Regulators around the world are attempting to keep up with these challenges. Mexico enacted several significant changes in 2018-2021. That includes a set of regulations called the New Network Code (*Nuevo Código de Red*) that have served as a template for other jurisdictions looking to build efficient power grids. Since Mexico formulated its new regulatory regime, similar regulations were adopted by India, Brazil and the European Union.

The energy infrastructure in the United States is far more mature than it is in many other markets, but the U.S. is experiencing all the same challenges, and U.S. energy companies are adopting many of the tools and techniques mandated by regulation elsewhere.

Here we’ll examine some of the challenges to the grid, some of the regulatory changes, and some of the technologies and techniques that the global energy industry is adopting in response. →

Managing new energy options

Balancing energy supply and demand has always required careful management and planning. Production must be carefully scaled up and down to meet immediate needs. Energy companies must ensure sufficient capacity to meet peak demand not only in the present but also in the future.

The growing reliance on renewable sources complicates energy system management. Wind and solar are both intermittent and less predictable. The different renewable options (hydroelectric, wind, solar, geothermal, etc.) produce electricity not only at different rates but also at different voltages.

The industry has responded by adopting more sophisticated modeling, management and control technologies.

Managing capacity is an intrinsic part of energy generation. Of equal and perhaps even greater concern is ensuring that the power is reliable, stable and used efficiently. For developing countries, reliable power is crucial to economic growth. Every watt of electricity is important, so many developing countries are either modernizing power grids or building them from the ground up to maximize resources and minimize losses.

Creating manageable grids

There is a growing consensus that generating and using power efficiently is best accomplished with decentralized though connected systems. This is expected to help make it easier to improve efficiency, decrease losses in power transmission and increase safety and reliability.

Mexico is at the forefront of this trend with its regulations that dictate connecting decentralized power generators to the grid. Its New Network Code mandates that connection or interconnection to load centers of the country's National Electric System (Sistema Eléctrico Nacional, or SEN) should not negatively affect the levels of efficiency, quality, reliability, continuity and sustainability of the SEN. Aside from ensuring security and safe operation of the grid, these regulations focus on three main areas:

- Establishing connection and interconnection criteria for load centers
- Improving power quality, including power factor correction and harmonic distortion
- Reducing wasted electricity during power transmission

Stability and energy loss

Transmission losses occur when electrical energy is lost due to the resistance of transmission lines during transmission and at converter stations that convert energy generated by power plants.

Electricity from power plants must be introduced into the grid at high voltages of 200 kV to 500 kV using direct current (DC) rather than alternating current (AC). DC is easier to control than AC, which helps with the interconnection of grids that have unsynchronized and inconsistent voltages at power generation plants.

Not only is DC easier to control, but high-voltage direct current (HVDC) systems and voltage-source converters (VSC) lose substantially lower amounts of electricity than AC transmission systems across long distances.

That said, voltage can become unstable across long distances. This instability can damage distribution systems, power infrastructure, transport and industrial equipment, let alone all the sensitive consumer electronics devices that energy customers will of course be plugging in.

Power capacitors and stability

Energy companies can install power capacitors with high current capability in load centers, the panel boards that are the main interface between the grid and a customer's facility, whether that's an office building or a residence.

Load centers that are thus equipped are more likely to be compliant with regulations, as they decrease the possibility of significant voltage fluctuations and surges.

Power capacitors may also be used at converter stations, the nodes in power systems that connect one segment of a grid to another. Power capacitors are critical for converting AC to DC, transmitting the power between HVDC converter stations and converting the DC back to AC so that electricity can be fed into the power grid. They essentially ensure the transmission of consistent voltage in the process.

Capacitor banks can also help stabilize the converted DC voltage in the power converter station as electricity is being prepared for long-distance transport. Capacitor banks safeguard and ensure the stability of AC output voltage in the receiving converter station before electricity is introduced into the grid.

Power capacitor solutions enable more remote and environmentally friendly, renewable power generation, providing more efficiency with fewer losses.

Source: TDK Electronics

Power capacitors and efficiency

Increasingly, power factor, a measure of the effective use of power, is being specified in rules and regulations. Power factor is a combination of true (or working) power in kilovolts (kV) and reactive power in kilovolt-amperes-reactive (kVAR) divided by the apparent power, expressed in kilovolt-amperes (kVA). A power factor of, say, 0.85, means the system is 85% efficient.

As Mexico's new regulations kick in, it is requiring a power factor of 95%, an ambitious target that would put Mexico's grid at the forefront of efficiency among global power systems. That figure will rise to 97% in 2026.

As Mexico and other power systems around the world attempt to become more efficient, there is a growing emphasis on power factor correction (PFC), a technique for improving power system efficiency that relies on the installation of banks of power capacitors.

Reactive power represents a draw on the source. PFC involves drawing on the power stored in the capacitors to maintain reactive power levels, thereby reducing or even eliminating the need to draw on the source. The practical result from the standpoint of the power factor equation is that system efficiency is increased.

Source: TDK Electronics

Harmonic filters and efficiency

Harmonic distortions are caused by non-linear switching of supply voltages, and occur when using power semiconductor devices and rectifier circuits, for example.

Harmonic distortion is a problem for many reasons, not the least of which is that it lowers the power factor. As a practical matter, the customer is using power inefficiently (and ends up paying more for power), also risking damage to the equipment connected to a distorted power supply.

Eliminating harmonic distortion is accomplished by strategically installing harmonic filters. There are several types, including passive filters, active filters and hybrid filters, each with advantages and disadvantages that have to be considered when deciding which is most appropriate for any given power system application.

Decentralization

A decentralized system will reduce the likelihood of widespread outages, as a power outage at one of multiple power-generating sources will have a minimal effect on the entire grid.

The New Network Code sets forth strict guidelines to harmonize the requirements for generation, demand and HVDC facilities that are connected to the grid. There is a requirement for a power factor of 95%, but among the many other guidelines, voltage must range from 105 to 95, and there is a 50% limit on total demand distortion (TDD), for example.

As Mexico decentralizes, it has also created the opportunity for private companies to join the grid.

Mexico's New Network Code is both ambitious and strict, however, and many power companies are struggling with compliance. This presents a large opportunity for engineers to develop solutions that not only aid organizations to become more compliant but also provide needed energy throughout the world.

Voltage converters

The use of power capacitors solves several issues, but it is also problematic for power systems to store significant amounts of electricity.

The amount of electricity generated and fed into the overall electrical grid at load centers must be carefully matched in terms of voltage, hence the voltage requirements mentioned above adopted by Mexico in its recent regulations. This is also why it is problematic that different renewable energy sources generate electricity at different voltages – the voltages there must also be matched.

This is necessary because inconsistent voltage in transmission can damage sensitive equipment used in hospitals, data centers, universities and by the military.

Voltage regulation is accomplished with HVDC or VSC to provide constant and consistent DC voltage. These converters not only reduce the fluctuations in voltage but also reduce losses of electricity across longer distances.

HVDC/VSC and capacitors

HVDC and VSC systems tend to be used for long-distance transmission because they lose substantially lower amounts of electricity than AC transmission systems across long distances.

Voltage can become unstable across long distances, however, and as noted above, voltage instability can damage customer equipment. Again, power capacitors come to the rescue. They can be used to smooth out significant voltage fluctuations and surges. Power capacitors may also be used at converter stations to ensure the transmission of consistent voltage.

By ensuring the integrity and consistent transmission of electricity, load centers and converter stations that employ such HDVC systems, power capacitors, capacitor banks and harmonic filters can maximize resources, minimize electrical losses and provide stability. In doing so, engineers at both public and private-sector companies can increase innovation, stability and efficiency, while ensuring compliance with Mexico's New Network Code and to regulations and practices adopted elsewhere inspired by the New Network Code.

Conclusion

It is vital to ensure widespread access to reliable power. This is achievable with consistent transmission of electricity load centers and converter stations that employ the latest HDVC systems, power capacitors, capacitor banks and harmonic filters to maximize resources, minimize electrical losses and provide stability.

Developing countries may have greater latitude to implement ambitious power system regulations and innovations largely because they are still building their electricity infrastructure.

The United States, the UK and Canada have more mature systems that are harder to modernize given the preponderance of legacy infrastructure they all rely on. That said, in many places, national grids interlock. There are benefits to thinking about regional power management where the regions don't necessarily map to national or state boundaries, and even mature markets will want to modernize, improve their operations and participate in regional power management schemes.

There are multiple solutions to address the requirements of new and evolving regulations and practices, including power capacitors, harmonic filters, power factor correction inductors, surge protection modules, reactors, and passive and active filters that assist engineers in creating compliant solutions.

Providing reliable power is achievable with consistent transmission of electricity load centers and converter stations that employ the latest HDVC systems, power capacitors, capacitor banks and harmonic filters to maximize resources, minimize electrical losses and provide stability.

Energy markets will continue to evolve. Consequently, issues such as decentralized multiple-source power and voltage stability and power loss will remain prevalent as governments and private stakeholders work to bring reliable access to electricity to a more stable grid.

ABOUT THE AUTHOR:

Eduardo Drehmer is a director of marketing at TDK Electronics. He has 28 years of experience in film capacitors product management and holds a Bachelor of Science degree in electrical and electronics engineering from Federal University of Rio Grande do Sul (UFRGS) of Brazil and an MBA from FGV of Brazil.

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MEET SUSAN STONE WITH BLUE CURRENT

ELISABETH MONAGHAN

This past fall, Susan Stone joined Blue Current, a startup manufacturer of fully dry solid-state batteries, as its CEO. We had the opportunity to speak with her shortly after she stepped into her new position. Following are highlights from our conversation.

EET&D: How would you describe your role at Blue Current?

SS: Like most CEOs of startup companies, my role is to do whatever is needed. As a startup executive, every day is different. Sometimes, that means putting out fires all day, and sometimes, it means being locked away in a room to work on business goals or put together a presentation. If I step back, the main thing that inspires me about working in technology – particularly in early-stage technology – is the opportunity to bring something new to life.

Kevin Wujcik, the co-founder and CTO of Blue Current, and I work closely together on our overall strategy and how it maps to the manufacturing organizations. I'm not an inventor, but Kevin is one. He also takes primary responsibility for most of the technology, which allows me to focus more on the strategy and business side of the house.

EET&D: What excites you about Blue Current and your work?

SS: The opportunity to help bring something new to the market and make an impact are the things that drive me. Right now, we're a company of only 50 people, so we have to be scrappy, but I find that exciting, too. To get to lead a small band of renegades here, combined with our mission to change the world with our batteries – especially as a small team – and to be involved in the early stages of the company, is just so fun and inspirational for me.

I love organization building, which is also one of the reasons that I saw Blue Current as such a great fit. We're at an inflection point, where we're moving this organization from R&D to true commercialization. To do this, we're scaling up the size of our team and also the scope of our team's responsibilities, so I'm also excited about the opportunity to work with Kevin and the rest of the team to build out processes we can scale.

EET&D: How did you end up at Blue Current?

SS: I found my way to Blue Current through conversations in my professional network. I happened to be available at exactly the same time that Blue Current's board was looking for new leadership. In that sense, it was very opportunistic, but it was also the result of maintaining professional relationships.

EET&D: What about Blue Current's technology excites you the most?

SS: I want to live in a world with safe batteries, which is also part of Blue Current's mission, and its goal when the company launched 10 years ago. We've gotten to this point by not following the rest of the industry's North Star – which is energy density. Instead, we follow the North Star of safety by producing a battery that is as good as or better than state-of-the-art, but with safety as a first principle. That means that the team had to discard materials at the chemistry level that were reactive or unsafe. What we've ended up with is a safe, fully dry, solid-state battery.

EET&D: Would you elaborate on this?

SS: When you think about existing lithium-ion batteries, they have a flammable liquid electrolyte, which is a part of the battery design. Unfortunately, it can't be replaced and can't be substituted. Now, think about batteries and how we cram so much energy there. When batteries are electrified, that energy has to be released, and if there is fuel present when that energy is released, you have a fire.

Our team's approach is to remove that liquid and make a solid-state battery that is fully dry. Most manufacturers working on a fully dry, solid-state battery are using an anode material called lithium metal, which is an amazing material. There are several great reasons that folks are using it, but it's also hard to work with because it's reactive and tough to scale.

So, about six years ago, Kevin and his team started to focus on using silicon in our anode. (Kevin and I like to tease that silicon is a pretty magical material. It's earth-abundant, non-toxic and can store substantially more energy than graphite.) That means we have developed a battery that we're just about to bring out of R&D that is as good as state-of-the-art lithium-ion across performance metrics. When you think about energy density and rate capability (*e.g.* how fast you can charge its cycle life and how many times it can cycle, etc.), we're able to meet the current industry standard, but we're able to do that in a way that eliminates lithium metal and eliminates a liquid electrolyte, which is much safer than batteries that contain those materials.

EET&D: How do you see Blue Current's technology fitting into the electric energy space?

SS: The first applications for technology like ours are going to be in some aspect of transportation. The EV industry and the auto industry overall have been eager for this technology. They all have programs in place, and we are already seeing folks bringing technologies that are similar to ours to market. I think that's where we will start as well, but the beautiful thing about the progress of bringing batteries to market is that you start where we are today, which is that we make R&D cells.

This year, we will be bringing up our pilot line, which allows us to make larger cells more repeatedly on manufacturing equipment. We have developed our process to be the same as – or as close as possible to – existing lithium-ion processes, which will allow us to produce more cells that we can sample with other customers and build into other plant configurations. →

Brandon Tinianov is our vice president of strategy and business development. We knew each other before I joined Blue Current. One thing that he and I are both passionate about is distributed storage, particularly home storage. I'm a proud owner of two Tesla power walls that have powered my home many times. When I think about ways that our technology could be deployed outside of mobility, the idea of home storage keeps scratching at the back of my brain because residential is a place where we can't tolerate fires and where energy density and being able to fit a lot of energy into a small space is appealing.

While I don't think anyone would bother to use silicon solid state or solid state at all for a big utility scale, there are certainly pockets where safety is paramount. Those are the areas where we're looking to specialize and find applications. We do a lot of work with mobility and transportation. That's probably a no-brainer, given the features of our battery. But we love to find those other segments where safety is so important.

EET&D: What advice would you give to anyone interested in pursuing a career in the electric energy sector?

SS: I think it's essential that we talk about more than STEM, not just for women but across the board. A lot of people got into technology accidentally, and the technology side of energy has changed dramatically over the past 30 years. It's just this natural evolution. So, I think it is good to remind people that there is an entry point. You don't have to have done it in high school or college, or even have to be an engineer. You could be a marketer, a finance person, or an accountant. We need all of those people, so I think that communication and relationship building and maintaining is huge. The career opportunities that electric energy presents are so obvious to those of us who are professional communicators or with more outgoing personalities, but you get a lot of really introverted people, who are also interested in careers in energy. It's just a matter of being aware of it and knowing there are opportunities for a variety of skill sets.

EET&D: Now that there is a new administration in the White House, do you see the conversation around the energy transition changing?

SS: The energy transition is happening, and it's happening around the world. It is in motion, and I think advances in energy storage unlock energy transition, and batteries are fuel-agnostic. The energy transition is not going to stop. In some ways, that insulates us a little bit from the political climate. I also think that it relates to safe batteries and electrification, whether it's in the U.S. or globally. The things I've seen that have driven real change have been sustainable businesses that provide real value to customers.

Something for us all to remember is that if we're building businesses that provide value to our customers and are sustainable in the long term, we shouldn't be as exposed to the political climate or even sentiment. One of the things I think about EVs overall is when EVs started to take off – especially when Tesla introduced a vehicle that was best in class and delighted customers because it had enough range to feel like an internal combustion vehicle. Many people who bought those vehicles in the early days of EVs bought them because they were awesome. They didn't buy them because they were green. That's how we approach our technology at Blue Current. Rather than just providing next-gen batteries, we provide great value to our end customers and supply chain partners. Just by virtue of energy being energy, the energy transition is going to move forward.

ABOUT SUSAN STONE

Susan Stone is CEO at Blue Current, a startup designing high-performing solid-state batteries. As an award-winning entrepreneurial leader, she specializes in growing companies with disruptive technologies to commercially scale and transform the industries they serve. Stone was previously CEO of solar technology company Ubiquitous Energy. Before her executive leadership in climate tech, she was the founder and CEO of Sierra Wasatch Capital, an early stage venture capital firm. Stone managed early stage investing for Riverhorse Investments, Inc., worked at JPMorgan in New York, as well as Houlihan Lokey in Los Angeles. Stone is also a former investment banker in mergers & acquisitions. She holds an MBA from Georgetown University's McDonough School of Business and a bachelor's degree from Yale University.

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