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POWER SYSTEMS TECHNOLOGY

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TRANSFORMER TECHNOLOGY MAG

NEW TECHNOLOGIES FOR GRID MODERNIZATION

WHAT'S NEXT FOR THE POWER INDUSTRY?

Richard Harada: Modern Monitoring Technology for Renewable Resources

Visiting DuPont's European Technical Center: Pioneering Innovation in Transformer Insulation

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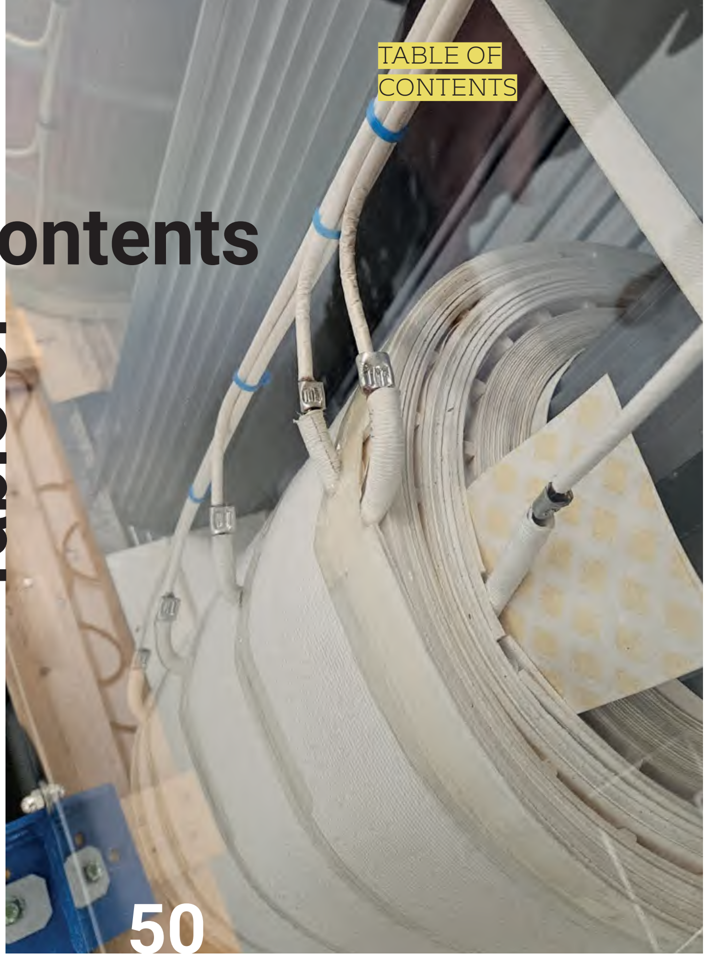

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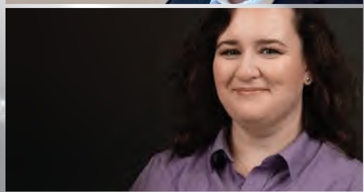

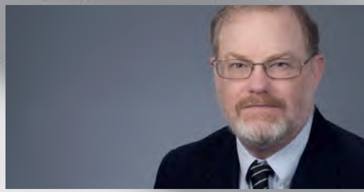

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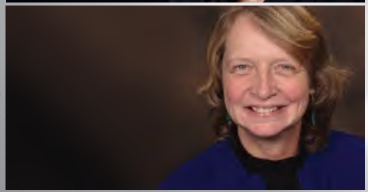

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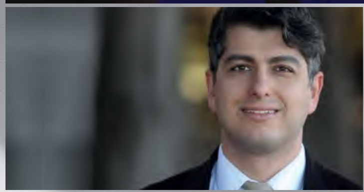

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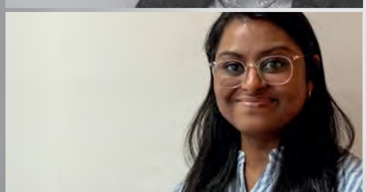

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Why We Need a Digital Revolution in Energy

We hear the call for a digital revolution in the electric power industry, but that means a lot of things to many different people. While it reflects the urgent need to modernize and transform how we generate, distribute, and consume electricity, at its core, this revolution is about leveraging advanced digital technologies to create a more efficient, resilient, and sustainable energy system.
Why is it crucial?

Firstly, the digital revolution in the electric power industry is about integrating smart technologies to enhance grid management. A digital-centric system allows for real-time monitoring and management of power flows, enabling utilities to optimize energy distribution, reduce losses, and quickly respond to outages or disruptions. For instance, smart grids can automatically reroute power in the event of a line failure, minimizing downtime and improving reliability.

The digital revolution can facilitate the integration of renewable energy sources. As the world increasingly turns to solar, wind, and other renewable energies to combat climate change, the variability and distributed nature of these sources pose significant challenges to traditional grid systems. Digital technologies can help address these challenges by providing the tools needed for better forecasting, load balancing, and energy storage management.

Photo: Shutterstock

Another critical aspect of the digital revolution is empowering consumers through greater transparency and control over their energy usage. With digital platforms and applications, consumers can access detailed information about their energy consumption patterns, costs, and carbon footprint. Furthermore, digital solutions can enable demand response programs, where consumers are incentivized to reduce or shift their energy usage during peak times

The digital revolution will drive innovation within the energy sector. By embracing digital technologies, utilities and energy companies can develop new business models and services, such as virtual power plants, peer-to-peer energy trading, and energy-as-a-service offerings. These innovations not only create new revenue streams but also enhance customer engagement and satisfaction.

> **By embracing digital technologies, utilities and energy companies can develop new business models and services, such as virtual power plants, peer-to-peer energy trading, and energy-as-a-service offerings.**

What will it take to accomplish this digital revolution? There is a need for collaboration among stakeholders, including governments, utilities, technology providers, and consumers, to ensure a coordinated and inclusive approach. Some, but not all of the things we must overcome are:

- **Infrastructure and Investment:** The existing power grid in many regions is outdated and not equipped to handle the demands of modern digital technologies. Upgrading this infrastructure requires significant financial resources, which can be a hurdle for both public and private entities.

- **Cybersecurity Concerns:** As the power industry becomes more digitalized, it also becomes more vulnerable to cyber threats. Ensuring robust cybersecurity measures are in place is crucial to protect the grid from potential attacks. This requires not only advanced technology but also skilled personnel to manage and respond to threats.
- **Regulatory and Policy Challenges:** The regulatory environment can be a barrier to digitalization. Existing regulations may not be conducive to the adoption of new technologies, and the process of updating these regulations can be slow. Policymakers need to create a framework that encourages innovation while ensuring safety and reliability.
- **Interoperability and Standardization:** The power industry involves a wide range of technologies and systems from different vendors. Ensuring that these systems can work together seamlessly is a significant challenge. Developing and adopting industry-wide standards is essential for interoperability, but achieving consensus among stakeholders can be difficult.
- **Skill Gaps and Workforce Training:** The shift towards digitalization requires a workforce with new skills in areas such as data analytics, cybersecurity, and digital system management. There is a need for comprehensive training programs to upskill the existing workforce and attract new alent to the industry.

There is a need for collaboration among stakeholders, including governments, utilities, technology providers, and consumers, to ensure a coordinated and inclusive approach.

Addressing these barriers requires a coordinated effort from industry stakeholders, policymakers, and technology providers. By working together, they can create an environment that fosters innovation and supports the transition to a more digitalized and efficient power industry.

Alan M Ross
CRL, CMRP
Managing Editor
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Technical Director

Alan has decades of experience in the power systems industry and is one of the greatest reliability experts out there.

As these new assets and technologies are introduced to the electrical grid, they add complexity to an already vast and complex system. Unique maintenance requirements, additional equipment and assets, and the need for specialized skills all mean that utilities must consider the way renewable energy sources will affect their system performance as they transition.

Modern Monitoring Technology for Renewable Resources

by **Richard Harada**

As utilities transition to lowering their emissions, additional types of assets and technologies are being added to the network and the design of the network itself is changing to accommodate new generation sources and new ways to transport and store energy. There are new asset types that need to be monitored and maintained including those contained in renewable generation sites, HVDC, and BESS facilities.

As these new assets and technologies are introduced to the electrical grid, they add complexity to an already vast and complex system. Unique maintenance requirements, additional equipment and assets, and the need for specialized skills all mean that utilities must consider the way renewable energy sources will affect their system performance as they transition.

This article will highlight some of the ways that thermal & visual sensors can overcome the challenges associated with expanding wind and solar capacity by reducing maintenance costs, enhancing reliability, and mitigating the risk of asset failure by shifting to a condition-based maintenance plan.

Green energy sources such as wind and solar were once viewed as technologies with potential. They were exciting because they presented an opportunity to move away from high-emitting energy sources such as coal, oil, and natural gas. But, until recently, they had yet to prove that they were economically viable or efficient enough to make up a significant portion of the energy mix.

Today, sustainable energy sources not only compete with traditional energy sources, but in many cases surpass them.

Though important, governments alone are not driving the transition. Building and operating renewable generating facilities such as wind and solar are now largely more cost-effective than traditional coal-fired power plants. In fact, a 2021 Deloitte report showed that up to 91 percent of existing US coal-fired capacity had operating costs higher than new solar or wind.

Utilities now have a mixture of traditional (hydro, nuclear, and fossil–fuel) generating assets and new technologies (wind, solar, and others) that have completely different behaviors.

This mix, especially as utilities maintain and support existing investments, requires greater coordination, not only to ensure that energy is available to meet changes in demand, but also to conduct maintenance, repairs, and upgrades on a wider range of equipment.

Photo: Systems With Intelligence

Richard Harada heads the Marketing and Product Management teams at Systems With Intelligence and he has over 20 years of experience in industrial networking communications and applications. Richard's role at Systems With Intelligence is ensuring that products are developed to solve customer needs. Richard has previous work experience at RuggedCom and Siemens Canada where he was focused on business development and product management for communications in the electric power market. Richard is an Electronic Engineering Technologist and has a Bachelor of Science degree in Computer Science from York University in Toronto.

Looking at wind, for example, only 20-25 percent of the total production costs can be attributed to ongoing operations, compared to as much as 60 percent for a natural gas-fired plant. These higher operating costs become even more relevant as fuel prices continue to fluctuate in response to global volatility.

The Impact of Renewables on Energy Infrastructure

Despite the advantages and obvious need to shift toward renewable energy, introducing new generating sources also introduces more complexity.

Consider the maintenance requirements for wind turbines. It's not a simple task to dispatch a technician to conduct an inspection. They need special training to work at heights and must be familiar with both the internal and external components of the turbine. As a result, a single turbine can take hours to inspect, and with larger wind farms having tens or hundreds of turbines, this quickly becomes unsustainable. In the same way, large solar farms spread across wide geographic areas require a significant ongoing effort to maintain and repair.

Utilities now have a mixture of traditional (hydro, nuclear, and fossil–fuel) generating assets and new technologies (wind, solar, and others) that have completely different behaviors.

MONITORING TECHNOLOGIES FOR RENEWABLE SOURCES

Beyond the generating assets, newly installed capacity requires other equipment and infrastructure. Many new facilities are deploying large-scale batteries to overcome the challenges of intermittency associated with wind and solar. Batteries introduce further maintenance requirements and demand different skills and expertise from the technicians who work on them.

Finally, the added capacity must be transmitted and distributed to customers to be useful. This can be done in several ways depending on the needs of the utility. For example, they may decide to run a single, high-voltage line to a larger transmission substation, or they may decide to connect multiple lower-voltage lines to distribution centers closer to the point of use.

Regardless of the approach, each new connection introduces new assets and additional points of failure that must be managed by the utility.

How Thermal & Visual Sensors Ease the Transition to Renewables

Given this added complexity, utilities need to shift away from traditional, scheduled maintenance and manual inspections. Instead of relying on expensive truck rolls and frequent physical inspections, thermal and visual sensors allow utilities to conduct automated, remote monitoring of high-value and critical assets throughout the electrical grid.

With continuous, 24/7 data, utilities can detect potential issues and diagnose the cause before a catastrophic failure occurs. Repairs can then be prioritized based on the severity of the issue, ensuring technical resources are deployed efficiently and enhancing the overall reliability of the grid.

For example, **utilities can deploy sensors to monitor the condition of wind turbines** without sending technicians into difficult and remote locations. Small, low-power sensors with built-in communications can be installed in the nacelle of the turbine and monitor anything from the mechanical components such as motors and bearings to electrical components such as generators, transformers, and switchgear. These assets can be monitored continuously whether the wind farm is local or in the middle of the ocean and provide early notification of developing problems. As power from renewable sources is aggregated, monitoring the substations, transformers, and inverters will be critical as the power flows from generation sources to downstream consumers.

Due to its high efficiency, **High Voltage Direct Current, (HVDC), technology** is being increasingly used to transport power from remote generation sites to consumer locations. The HVDC converter halls are a challenge to monitor and maintain because once they are powered up, personnel cannot enter the buildings due to the hazardous, high-voltage conditions. Using modern sensors, the equipment inside the HVDC hall can be monitored continuously and most importantly, while the system is running and under load. Infrared monitoring can detect thermal anomalies in active components and detect issues or leaks in the cooling system. Using continuous, automated monitoring in HVDC converter halls can minimize the planned outage that would normally be scheduled for periodic inspections.

Photo: Systems With Intelligence

Using continuous, automated monitoring in HVDC converter halls can minimize the planned outage that would normally be scheduled for periodic inspections.

Utility-scale, Battery Energy Storage Systems, BESS supports the deployment and operation of renewable power generation. Integrating BESS with wind and solar power systems has the potential to increase the overall efficiency, reliability, and economic viability of these technologies while reducing greenhouse gas emissions.

The flexibility that BESS provides will help utilities overcome the variability of wind and solar. BESS facilities can respond almost instantaneously, making it easier to match supply with demand. The systems also allow operators to take advantage of price differences between peak and off-peak periods, stabilize the grid, or provide backup power for critical services.

Already, battery deployment in the power sector increased by more than 130 percent in 2023, adding a total of 42 GW to electricity systems around the world. However, accidents, fires, explosions, and arc flashes have occurred at BESS facilities which have damaged equipment and put workers at risk. These incidents, if not avoided in the future, pose serious threats to the development and adoption of BESS. In BESS sites, it is crucial to deploy continuous condition monitoring to avoid accidents and failures and not be dependent on periodic inspections.

Thermal sensors provide early detection and warning of sudden or prolonged temperature anomalies outside of a set range, while visual sensors allow operators to remotely view the condition of the asset, check gauges, verify the issue, and assess safety risks before dispatching a crew to the site. Having grid edge security with alarm management integrated into the overall solution ensures these valuable assets can be operated reliably in remote areas.

Utilities now have to manage a mix of traditional generating assets, renewable energy sources, and large-scale energy storage facilities. Each of these systems has completely different behaviors, lifespans, and maintenance requirements.

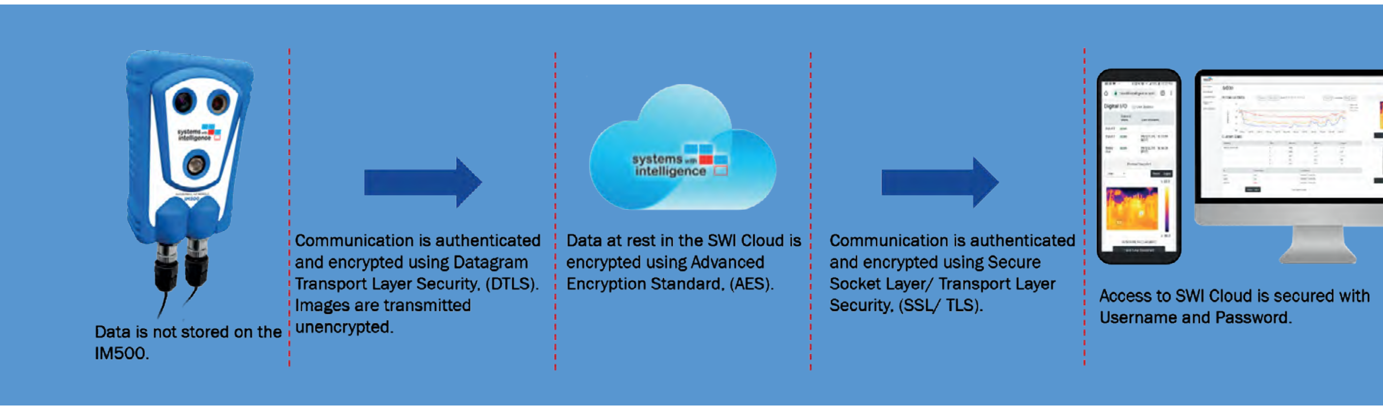
As a result, utilities require greater levels of coordination, oversight, and responsiveness. Given the nature of BESS facilities, the potential consequences of a catastrophic failure can be significantly higher than a typical substation.

Energy 4.0 Will Modernize Asset Monitoring

Energy 4.0 is a general term for the collection of hardware, software, and technologies that leverage connectivity, data, and computing power to modernize the grid. The Industrial Internet of Things (IIoT) is a network of physical devices or sensors that collect, exchange, and transmit contextual data.

Cloud computing is the on-demand delivery of computing services over the Internet, including servers, storage,

Given this added complexity, utilities need to shift away from traditional, scheduled maintenance and manual inspections.



Instead of relying on expensive truck rolls and frequent physical inspections, thermal and visual sensors allow utilities to conduct automated, remote monitoring of high-value and critical assets throughout the electrical grid.

With continuous, real-time thermal and visual data, operations and maintenance teams can allocate resources more effectively, reduce the cost of maintenance and repairs, and improve reliability through condition-based maintenance programs.

databases, networking, software, analytics, or other IT services. Data and analytics allow utilities to collect, store, and use data from multiple sensors to improve decision-making, business processes, and performance. A recent study found that 32 percent of electric utilities had already or were currently implementing big data analytics. [iv]

Artificial Intelligence (AI) allows computers to analyze and contextualize data to provide information or automatically trigger actions without human intervention. Machine learning (ML), on the other hand, is a subset of AI that uses algorithms to automatically learn and recognize patterns to make increasingly better decisions.

Advanced thermal and visual sensors allow utilities to monitor the condition

There are significant advantages to this approach, not least of which is that it does not require utilities to build and manage a network for each substation.

Embracing Technology for Long-Term Success

Accelerating trends toward renewable energy, distributed grids, labor shortages, and more frequent and severe weather events are taking a toll on aging infrastructure that was not designed to meet the challenges of the future.

Remote Asset Monitoring using contactless thermal and visual sensors provides utilities with a continuous view of high-value, critical assets while minimizing the need for physical inspections.

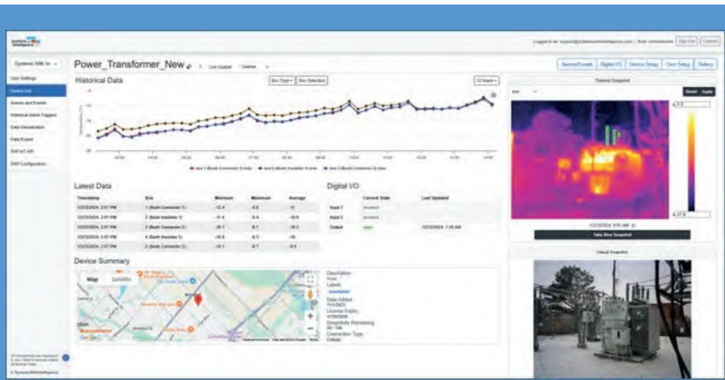


Photo: Systems With Intelligence

of remote assets from a centralized location. With continuous, real-time thermal and visual data, operations and maintenance teams can allocate resources more effectively, reduce the cost of maintenance and repairs, and improve reliability through condition-based maintenance programs.

Utilities have two primary choices to connect to the sensors and access the data. Traditionally, they would turn to their IT department to build an internal network, invest in IT infrastructure, install software on user devices, and individually update software whenever a new version was available.

Today, however, many utilities are transitioning to the cloud and accessing their data through an easy-to-use online dashboard.

With greater access to historical and real-time data, utilities can mitigate the risk of catastrophic failures, prioritize strategic investment decisions, and reduce the burden on scarce technical resources.

By implementing effective security policies and IIoT architecture, utilities can achieve the benefits of Energy 4.0 technologies without compromising sensitive data or critical equipment. Energy 4.0 technologies including IIoT, cloud computing, data and analytics, and AI/ML are changing the way that electric power and its critical assets are managed and maintained. By making the right investments today, electrical power utilities will be better positioned for long-term success and profitability.

Bridging the Gap: How Accessible Technology is Transforming Asset Management

by **Martin Robinson**

The asset management industry is at a crossroads, and let's be blunt: it's no longer sustainable to rely on the traditional ways of doing things. The accelerating loss of skilled workers due to retirement and attrition, coupled with the increasing complexity of modern systems, has left many organizations scrambling to maintain the reliability, resilience, and safety of their operations. It's a stark reality—one that demands a bold response. That response lies in the democratization of asset management technology.

This isn't about "new shiny objects" or speculative trends. This is about real, practical solutions that empower teams to achieve outcomes once reserved for seasoned experts with decades of experience.

From intuitive tools that simplify inspections to advanced AI-driven systems that enhance decision-making, the spectrum of "new tech" is transforming the industry. This is the essence of the citizen worker concept—using AI-assisted systems to democratize expertise, enabling individuals at all skill levels to take on complex tasks with confidence and precision. But, as with any transformation, there are hurdles: distrust in technology, a reluctance to change, and the need for reliable data to build confidence in these systems. Let's address these challenges head-on, because the stakes are too high to ignore. The time for half-measures and complacency has passed—organizations that fail to adapt risk falling irreparably behind.

Imagine receiving not just an alert about a critical issue, but also a fully drafted schedule, procurement list, and even suggested communication templates for stakeholders. Generative AI doesn't just support decisions—it anticipates needs, creates solutions, and empowers teams to act decisively.

Martin Robinson is the founder and CEO of IRISS Inc., a global technology company specializing in industrial-grade Electrical Maintenance Safety Devices. Founded with a vision to enhance the safety, efficiency, and reliability of electrical systems, IRISS Inc. has become a global leader in electrical maintenance and safety. For more than 30 years, Robinson has been a pioneer in the field of condition-based maintenance technology. He continues to be an innovator and pioneer the technological benefits of Electrical Maintenance Safety Devices (EMSD's), Operations Driven Safety and Reliability (ODSR), and sustainability in electrical system testing.

By synthesizing data from IoT sensors, historical records, and real-time inputs, AI can cut through the noise to deliver insights that matter. Instead of overwhelming users with raw data, it simplifies their decision-making process—turning complexity into clarity.

The New Technology Spectrum

Low-Tech Innovation: Simplicity at Its Best

Not all technological advancements need to be complex to be revolutionary. Take thermochromic overtemperature indicators, for example. These simple, power-free tools are redefining electrical safety. They change color to indicate overtemperature events on equipment, providing an immediate, intuitive visual cue that even the least experienced technician can act on. No training manuals, no overcomplications—just actionable information at a glance.

These tools represent the low-tech end of the spectrum, but their impact is anything but minor. By addressing basic safety concerns with simplicity and reliability, they reduce human error, prevent costly downtime, and, crucially, save lives. This is the essence of democratized technology: making vital insights accessible to everyone, not just the experts. The power lies in its immediacy and its ability to remove barriers for less experienced operators while maintaining the highest safety standards. When implemented correctly, these solutions offer a reliable first line of defense against common operational risks.

Data-Driven Insights: The Power of IoT

On the other end of the spectrum, we find IoT-enabled solutions. These systems bring a new level of sophistication to asset management, allowing organizations to collect, monitor, and analyze vast amounts of data in real-time. Sensors embedded in equipment relay critical information to dashboards that turn raw data into actionable insights. The result is a smarter, more informed workforce, equipped with the tools to handle increasingly complex systems.

We're working to further develop and refine our own data management system that tracks asset performance and maintenance with an NFC-enabled approach, exemplifying how IoT can simplify and streamline asset management. Imagine a technician in a substation scanning an NFC tag with their smartphone to instantly access the equipment's full maintenance history, upcoming tasks, and even warnings of elevated risk. This level of accessibility reduces guesswork, speeds up decision-making, and ensures that even a relatively inexperienced team member can act with confidence. By integrating IoT solutions into existing workflows, organizations can gradually scale their technological capabilities without over-whelming their teams. The payoff? Improved efficiency, reduced errors, and a team that operates with confidence and precision.

AI: Turning Data Into Decisions

Artificial intelligence is a real game-changer in asset management. I'm talking about AI-driven systems that analyze data, identify patterns, and prioritize actions based on urgency and impact.

Consider this: an AI system processes thousands of data points from an organization's infrastructure and flags the three most critical maintenance issues that, if unaddressed, could lead to catastrophic failures. But with Generative AI, it doesn't stop there. Instead of simply identifying issues and offering generic recommendations, Generative AI dynamically generates detailed, tailored action plans. These plans might include step-by-step maintenance instructions, predictive timelines for resolution, or optimized resource allocation strategies that minimize downtime and costs.

Imagine receiving not just an alert about a critical issue, but also a fully drafted schedule, procurement list, and even suggested communication templates for stakeholders. Generative AI doesn't just support decisions—it anticipates needs, creates solutions, and empowers teams to act decisively.

AI also has the potential to drive sustainability efforts. By optimizing energy usage and predicting equipment failures, AI reduces waste and helps organizations minimize their carbon footprint. These aren't abstract benefits; they're tangible, measurable outcomes that directly impact the bottom line. AI's ability to analyze historical and real-time data ensures that no insight is lost in the shuffle, creating a foundation for continuous improvement across operations. The ability to contextualize massive amounts of data—transforming it into actionable strategies—is what separates leading-edge organizations from those stuck in the past.

Over-coming Barriers to Adoption

Distrust in Technology

A significant challenge in adopting new technology is the lack of trust from operators and technicians. When a sensor sends an alarm about a potential fault, the instinct is to double-check with a thermal imaging camera or another trusted tool before taking action. This distrust is a major roadblock, but it's not insurmountable.

The solution lies in transparency. AI and IoT systems need to be explainable, not just functional.

Operators need to understand how a system reached its conclusions, and they need to see consistent, reliable results over time. Building trust is a process, and it requires clear communication from technology providers to their end-users. It also means integrating systems that allow human oversight, ensuring that operators remain the final decision-makers. Trust cannot be forced—it must be earned, and it starts with reliable, repeatable outcomes that align with operator expectations.

Data Complexity and Integration

Another challenge is the sheer volume and complexity of data these systems generate. Having diverse data sources is a double-edged sword: while it enhances reliability and accuracy, it also makes integration more challenging. Organizations need systems that can consolidate and contextualize this data to make it actionable.

This is where AI shines. By synthesizing data from IoT sensors, historical records, and real-time inputs, AI can cut through the noise to deliver insights that matter. Instead of overwhelming users with raw data, it simplifies their decision-making process—turning complexity into clarity. Imagine an integrated platform where technicians can view predictive maintenance schedules, past performance data, and current operational metrics all in one place. By investing in such systems, organizations can bridge the gap between data overload and actionable intelligence, enabling teams to work smarter, not harder.

Photo: Shutterstock

Leaders need to foster a culture that embraces change, ensuring that their teams are equipped and motivated to integrate new tools effectively.

By spotting potential failures before they happen, AI-enabled systems can allow organizations to address vulnerabilities early, avoiding costly downtime and catastrophic failures.

Leadership Buy-In

Finally, there's the question of leadership. Let's be clear: if industry leaders don't champion these technologies, adoption will stall. Decision-makers need to see the ROI, not just in financial terms but also in improved safety, reliability, and sustainability.

The reality is clear: organizations must adopt these technologies or risk falling behind in an increasingly competitive landscape. Leaders need to foster a culture that embraces change, ensuring that their teams are equipped and motivated to integrate new tools effectively. This is where visionary leadership—the kind willing to take calculated risks—can make all the difference.

Democratizing Asset Management

The beauty of democratized technology lies in its accessibility. Tools like E Sentry (our data management solution) and thermochromic overtemperature indicators exemplify this philosophy by simplifying complex processes and making advanced capabilities available to a broader audience.

E Sentry's NFC technology, for instance, doesn't just make asset tracking easier—it transforms it. Instead of relying on specialized equipment or lengthy training, operators can use their smartphones to scan tags, access data, and perform tasks with confidence. Similarly, thermochromic over-temperature indicators remove the guesswork from safety inspections, ensuring that even less experienced team members can contribute effectively.

This is technology working for people, not the other way around. By lowering the barriers to entry, democratized tools empower teams to achieve more, even in the face of workforce shortages and rising complexity. This isn't just about operational efficiency; it's about creating an environment where everyone—from frontline operators to senior engineers—can contribute to the organization's success. Democratization isn't just a concept—it's the linchpin of resilience in an industry that's evolving faster than ever before.

Resilience, Sustainability, and the Role of AI

Building Resilience

Resilience is a fundamental requirement for today's fast-paced, interconnected world. The ability to anticipate, withstand, and recover from disruptions is critical for success. AI can play a pivotal role here by enabling proactive maintenance strategies.

This dual benefit—environmental and financial—makes data-driven decision making a cornerstone of modern asset management strategies. It's not just about doing the right thing; it's about doing the smart thing, ensuring long-term viability in a rapidly changing world.

By spotting potential failures before they happen, AI-enabled systems can allow organizations to address vulnerabilities early, avoiding costly downtime and catastrophic failures.

Resilience also means adaptability. As systems evolve and new challenges emerge, AI-driven tools can quickly recalibrate and prioritize actions to meet changing demands. This flexibility is vital in industries where the margin for error is razor-thin, and the cost of inaction is enormous. The companies that embrace this adaptability will lead the charge into the next era of asset management.

Driving Sustainability

Sustainability isn't just a corporate responsibility; it's a competitive advantage. Technologies that optimize energy use, reduce waste, and extend asset lifespans directly contribute to an organization's environmental goals. Predictive maintenance, powered by this spectrum of new technologies, is a prime example. By fixing issues before they escalate, organizations can avoid unnecessary replacements and minimize resource consumption.

This dual benefit—environmental and financial—makes data-driven decision making a cornerstone of modern asset management strategies. It's not just about doing the right thing; it's about doing the smart thing, ensuring long-term viability in a rapidly changing world. Sustainability is no longer optional—it's the cost of doing business in an era defined by environmental accountability.

Technology as a Force Multiplier

Let's not sugarcoat it: the challenges facing the asset management industry are immense. But so are the opportunities. By embracing the democratization of technology, industry leaders can transform these challenges into catalysts for growth and innovation.

The tools are here. From simple, intuitive, zero-power indicators to advanced data management systems that drive analysis and decision-making, the spectrum of new tech is reshaping what's possible. The key is leadership. Without buy-in from the top, these technologies will remain underutilized, leaving organizations vulnerable to the very challenges they're designed to solve.

So, here's the challenge: stop waiting. Stop doubting. Embrace the tools that empower your teams and future-proof your operations. Because in the end, technology doesn't replace human ingenuity—it elevates it.

Reduce Waste.
Embrace Sustainability.
Excess energy. Unnecessary costs. A growing carbon footprint. Poorly maintained electrical systems drain resources.
That's why industry is turning to IRISS—to find inefficiencies, stop excess energy usage, and extend equipment life.
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Seamus Allan

Interview with **Seamus Allan**

LV & Distributed Monitoring Product Manager
at Dynamic Ratings

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> It has been exciting.

Photo: Dynamic Ratings

Ben Lanz: I am Ben Lanz, Executive Advisor to APC Media, which includes Power Systems Technology, Transformer Technology and Women in Power Systems magazines. We are here in Paris, France, at the CIGRE 2024 conference, talking with industry thought leaders to gain their insights into the trends, challenges, and solutions, and bringing those insights to you. Our guest is Seamus Allan with Dynamic Ratings.

Welcome, Seamus.

Seamus Allan: Thanks for having me, Ben.

BL Let me start with a question about yourself. How did you get your start in the industry?

SA That is a good question because I came into the industry as a software and hardware engineer. I thought I was going to be designing electronics and working in some dark room somewhere. I quickly moved into Dynamic Ratings where I was working on software and hardware initially. I could not believe the junction that this company has been working on at this microelectronic level, but also working on a 500kV network.

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That combination of micro and macro is exciting. I just fell headfirst into that because it is a lot of interesting solutions. It is great to be part of that.

BL Fantastic. Now you are the Global Product Portfolio Manager for all your products worldwide. What does that look like? Tell me a little bit about Dynamic Ratings in your role.

SA We come from a background of asset health management, focusing on online monitoring of asset condition. Measuring as many different data points as we can around particular large assets and then interpreting that data, ideally online, to be able to provide insights to customers to manage and maintain those assets in a more intelligent way is our pedigree. We came into an industry which, for the last 100 years, has done things by putting their hand on transformer tanks or listening to how circuit breakers sound. We felt there was a massive space to be able to take that data and do intelligent things with it, and to capture the knowledge of intelligent people who have been working in this industry for a long time. Those experts who were listening

I think that is creating a challenge in being able to make intelligent decisions about what to do and how to operate the equipment.

to the circuit breakers, they could tell when things were going wrong. We decided to try to work out how we could codify that on top of the measurements that we are taking and then basically make that more accessible for the newer generations and for other utility users.

BL I think you are hitting some of the points that I wanted to ask you about from your global perspective. What are some of the challenges that you see in the industry that we need to be solving or that are creating opportunities for Dynamic Ratings?

SA The senior engineers who have been around for a long time started as apprentices, and worked their way up into these knowledgeable positions, and now they are starting to retire. The talent pipeline has dried up. A lot of young engineers tend to be hopping around quite a lot. The idea of staying at the same job for 40 or 50 years is foreign to a lot of younger people.

There is an emerging knowledge gap of people that might be doing asset management for a transformer or a circuit breaker and who may never have actually seen one or touched one or looked inside one before. I think that is creating a challenge in being able to make intelligent decisions about what to do and how to operate the equipment. That is opening another door to ask ourselves how we can capture that information, that knowledge, as quickly as possible, and then make it accessible to others through tools that give them the results and then back that up further with services to remediate problems.

BL We have talked with several other thought leaders in the industry, and this is a reoccurring theme. You are saying that your technology and your solutions are enablers, so you can take all kinds of information and do what with it? How do you present that to the customer?

SA Sensing and measuring things are easy. We have done that for an exceptionally long time, and we are able to do that very reliably. We have various products and different families of things collecting data, which is interesting. But if you cannot do anything with that data, it is meaningless and it can create data overload. In many cases, even that data is just sitting out in the substations or on the assets inside boxes in little data islands.

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It is either that or they are connected into the traditional SCADA systems where the running joke is that this is where data goes to die. It goes to an operational system for people who are looking to do things at once, not for people who want to merely analyze the data and see what is going on.

BL Are the lights out or not, right?

SA Right, asking if this transformer is on its way out in the next 5 or 10 years, whatever it might be. We have been trying hard to get that data back from the substations and put it in the hands of the right people and in a format that they can digest and understand to take advantage of it. In the last 5-10 years, it has been a massive focus for our company to find out how we get that data back, how to make it all consistent and then how to leverage it to make it more accessible to the next generation. It has been exciting.

BL Is that where you are innovating mostly, that is, in that area of space of trying to get the data and assemble it in a way that has not just alarms going off everywhere, but actionable information?

SA Yes, actionable information and taking the best practices, which organizations like ours are talking about. There are these huge data sets and health indicators what we should be doing with them. Again, putting that into systems that can codify it, raise a flag and say, “come and take a look at this”, because based on CIGRE recommendation or an IEEE performance guide or whatever it might be; these are the actions you should be taking based on the measurements that we are taking down on the substation. That is making a substantial value out of the equipment in the substation and the people who are having to look at it.

BL That seems like a daunting task to help solve some of our asset management problems and energy resources. There are so many new systems, such as inverter systems, transients and so forth. This is creating a different environment for our grid. Here you are on the grid edge collecting that data and assembling it in a way that junior engineers and planners who are just coming into the industry and who are maybe attracted to the industry because it is neat and interesting, can access it. How do we create a scenario where we can use the information that we are collecting and solve some of these big industry problems?

SA The emerging problems are the exciting thing right now, aren't they? It is the same old network, but we have a whole new set of challenges on top of it. With all the inverter-based generation, the large loads with electric vehicles and whatnot, it is straining that network, which has been around for 100 years or more, with a whole lot of new challenges. The utilities cannot go out and replace their network or upgrade all the transformers or do anything like this. They must find ways to use this data, in a distinct way than they would have previously. You need control systems and management of those different challenges, which is stuff that no one could have foreseen 10 years ago, and now we are controlling the networks based on all different parameters than we did before. Having that data available and accessible and able to be manipulated is critical.

BL I heard a statistic that 10% of circuits in the US are capable of handling the loads that we are predicting coming. You and Camlin Energy have your work cut out for you, Seamus.

SA Yes, it is amazing. And everywhere we go in the world, in any of these events, you can see they are having the same conversations. They are saying, “we want to switch to a low-carbon economy, and it is going to require an awful lot of electrification which is going to increase the demand enormously”. Switching to the non-fossil fuel-based generation with the capacity factors of those stations means you must have a lot more of them. The network is not ready for all of that.

And the amount of work that is going to go into this over the next few decades is going to be phenomenal. I heard someone saying that it was like the electrification era in the early 1900s, where the networks grew at an extremely rapid pace. And in the late 1900s, it leveled off and plateaued for a little while industrialization leveled out. And we are now going through another spurt that will be an enormous growth for the networks. The people are not there, so that is going to be very much data-based and trying to use the tools that we must have. We have got to supplement the fact that we just cannot throw people at it anymore.

BL We are here at CIGRE 2024 in Paris, and it is exciting to be here with you and other thought leaders. What excites you about being here?

SA I think CIGRE is amazing because, again, it is one of those coalescences of people from all over the world who share their problems, their challenges, but also their discoveries. I like the idea that CIGRE stands

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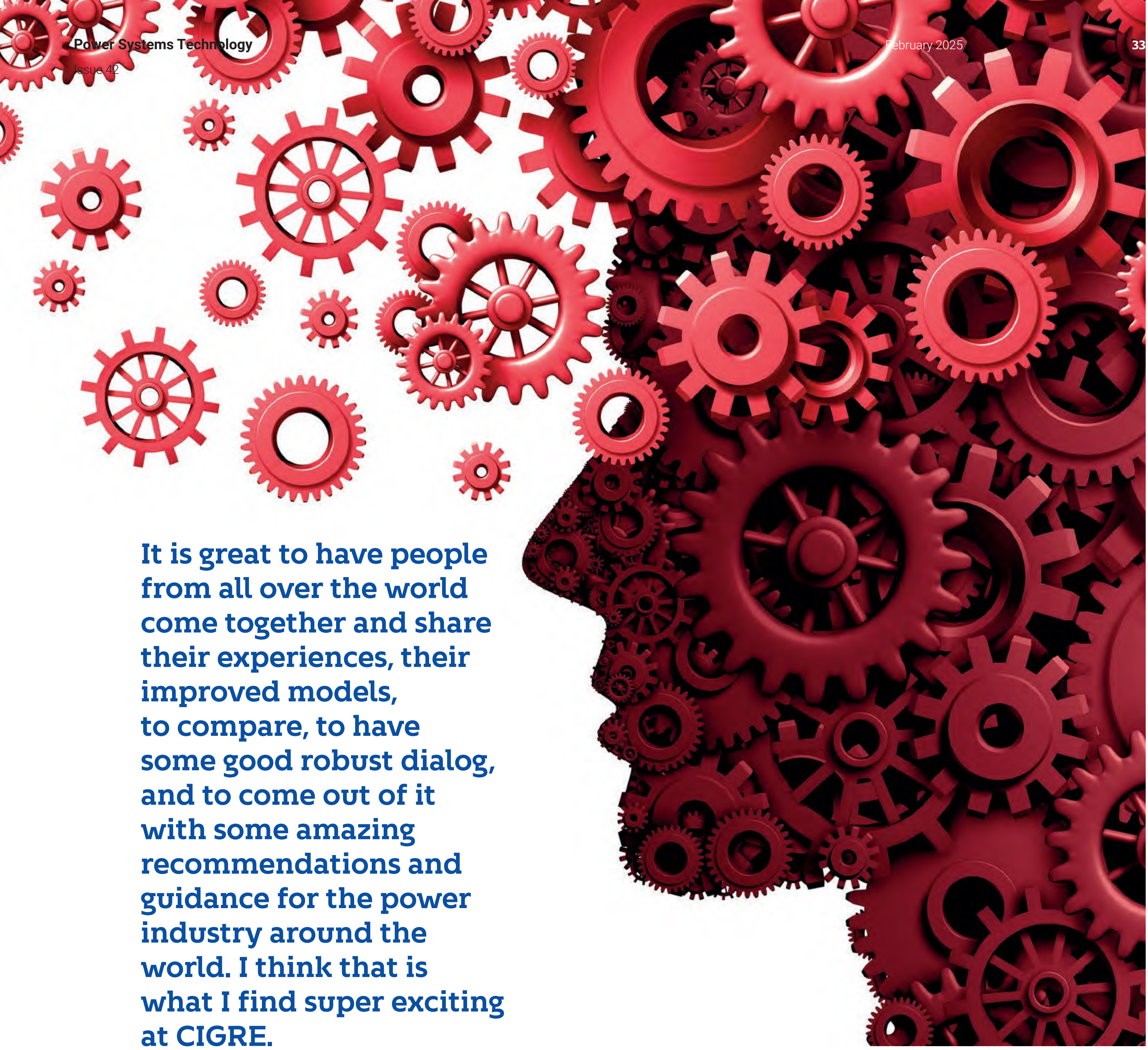


It is great to have people from all over the world come together and share their experiences, their improved models, to compare, to have some good robust dialog, and to come out of it with some amazing recommendations and guidance for the power industry around the world. I think that is what I find super exciting at CIGRE.

for the concept of not reinventing the wheel because utilities have a real tendency to keep looking inwards and solve problems themselves. Often, everybody is solving the same problem, everybody is moving power from A to B. It is what every utility in the world does. CIGRE is this terrific way to come together and say, "we are having this problem" and someone else says, "we have a solution. Do you want to try it out?" I sit in a working group for Dynamic Thermal Modeling of Power Transformers. It is great to have people from all over the world come together and share their experiences, their improved models, to compare, to have some good robust dialog, and to come out of it with some amazing recommendations and guidance for the power industry around the world. I think that is what I find super exciting at CIGRE.

BL Fantastic. I appreciate your insights into the industry, and it is fascinating to hear about all the solutions that you are bringing to solve some of those challenges.

Do you have any final comments for our audience that you would like to lay out there?

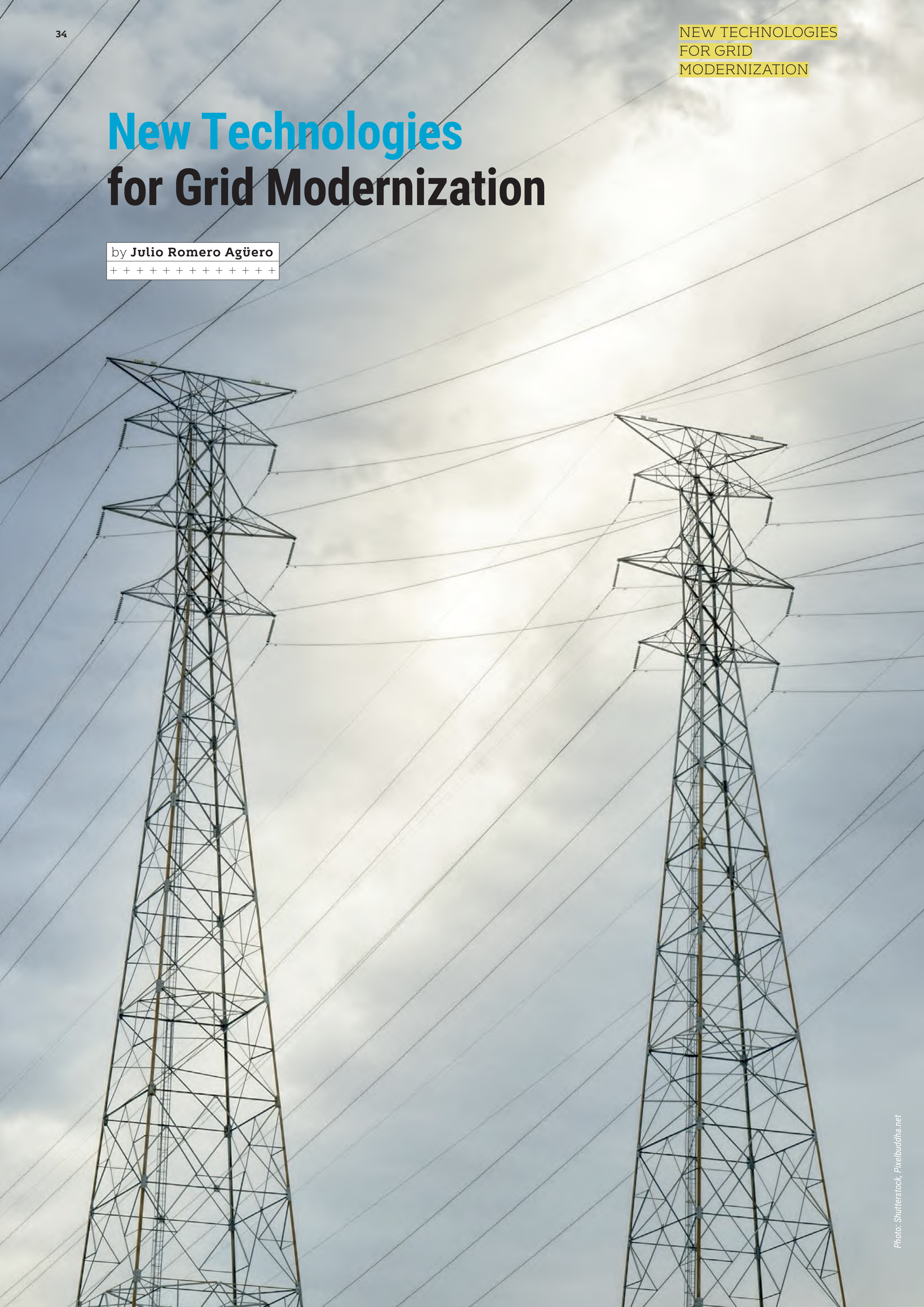
SA I encourage everybody to get involved in the industry organizations; to step out of their offices and share that knowledge and see what other people are doing. It is critical. Events like this really highlight the fact there is a great amount to be shared and a great amount to learn. If we do that, I believe we can dramatically increase the rate at which we solve emerging problems. That is only going to have a positive impact for everybody everywhere. If we can do more collaborative work, and through situations like this, I really recommend investing in learning, investing in relationships and networking opportunities. And sharing it with your peers.

BL Excellent, that is good advice. Seamus, thank you so much. It has been a pleasure.

SA Thank you as well Ben.

New Technologies for Grid Modernization

by **Julio Romero Agüero**



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The electric power industry is experiencing an unprecedented evolution driven by multiple important trends. For instance, in transmission systems, there is growing interconnection of renewable generation and retirement of fossil fuel power plants. In distribution systems, there is increasing integration of distributed energy resources (DER), particularly solar photovoltaic distributed generation, and electric transportation, as shown in Figure 1 and Figure 2, respectively. Key trends also include the adoption of energy storage, particularly battery energy storage systems (BESS), and the proliferation of data centers.

Additionally, customers have growing expectations regarding reliability, resilience, and power quality due to society's increasing dependence on the digital economy. This is particularly challenging given the vulnerability of power distribution systems (particularly overhead lines) to disruptions caused by more frequent and severe climate-related events (e.g., hurricanes, winter storms, wildfires, etc.) and major events in general, as shown in Figure 3.

Finally, there is an increasing need for considering the interaction effects between transmission and distribution systems, such as reverse power flows through distribution substations caused by DER integration. The complexity to design, plan and operate power delivery systems is increasing rapidly, particularly given the unbalanced nature of distribution systems, this is conceptually illustrated in Figure 4.

> **Most urban and suburban feeders are natural candidates for implementation of closed-loop operation to mitigate voltage increase and fluctuation issues and facilitate DER integration, since their topology is generally meshed, and their operation is radial.**

Dr. **Julio Romero Agüero** is Senior Vice President, Strategy & Business Innovation at Quanta Technology. He has 29 years of industry experience, he provides leadership to Quanta Technology in the areas of technology strategy, innovation, grid modernization, distribution systems planning, reliability, resilience, and integration of distributed energy resources and emerging technologies. He has developed solutions and provided advisory services and regulatory support in these areas to electric utilities and regulatory boards in the USA, Canada, Latin America, the Caribbean, and Asia. He is a Fellow of the IEEE and a Distinguished Lecturer of the IEEE Power and Energy Society (PES). He currently serves as Chair of the IEEE PES Transmission and Distribution Committee. He has served IEEE PES as a volunteer in multiple roles, including as Chair of the IEEE PES Distribution Subcommittee, Chair of the IEEE PES Working Group on Distributed Resources Integration, Editor of IEEE Transactions on Power Delivery, Editor of IEEE Transactions on Smart Grid, Vice President, Chapters and Membership in the IEEE PES Governing Board, and Chair of the 2020 and 2021 Innovative Smart Grid Technologies Conference. He has been an Adjunct Professor at University of North Carolina at Charlotte and University of Houston.

Figure 1
Cumulative Solar Installations (U.S.)[1]

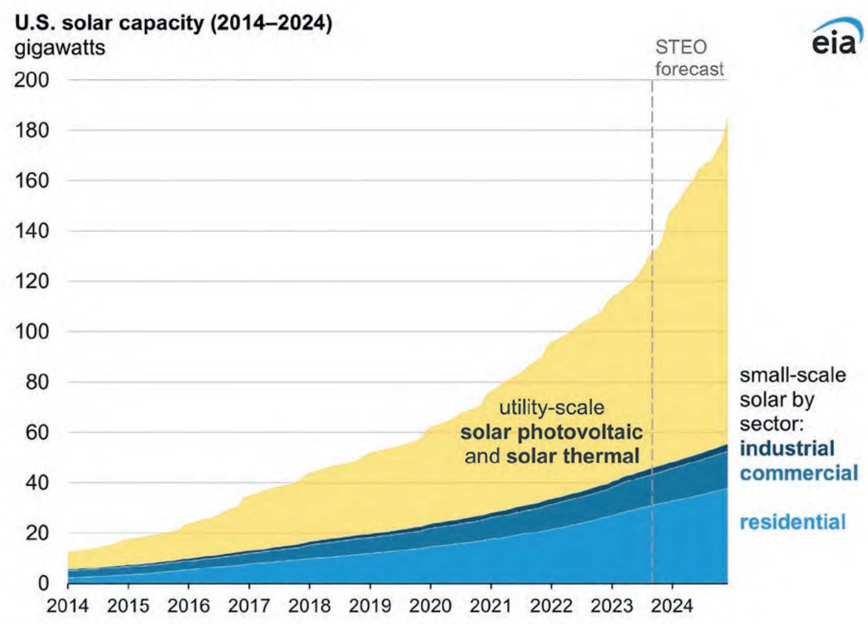


Figure 2
Total Monthly EV Sales (U.S.)²

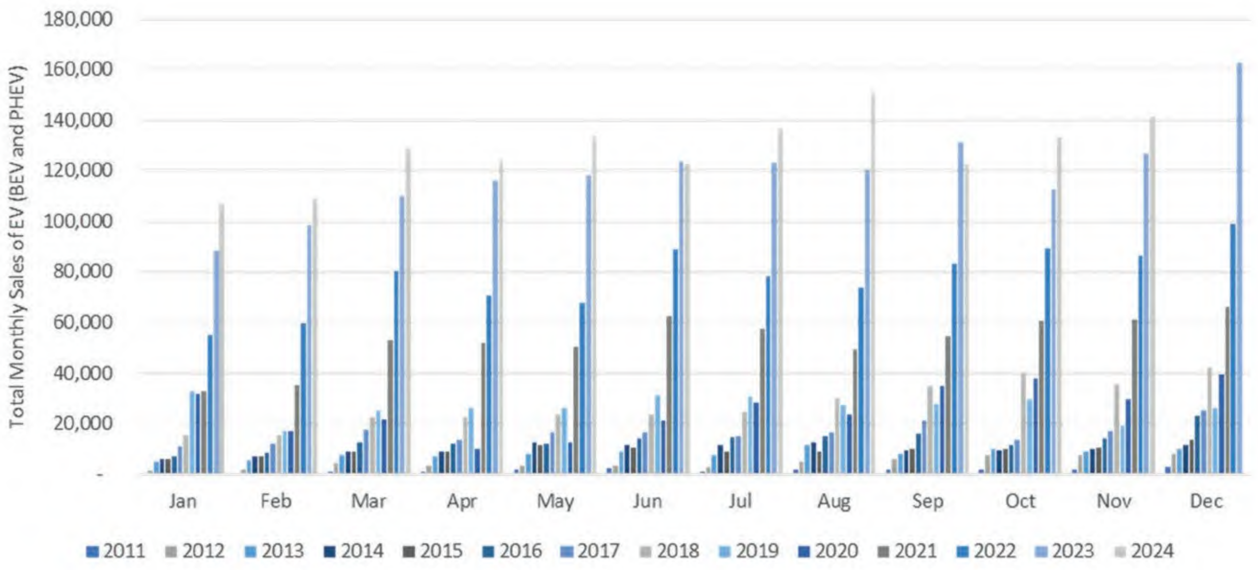
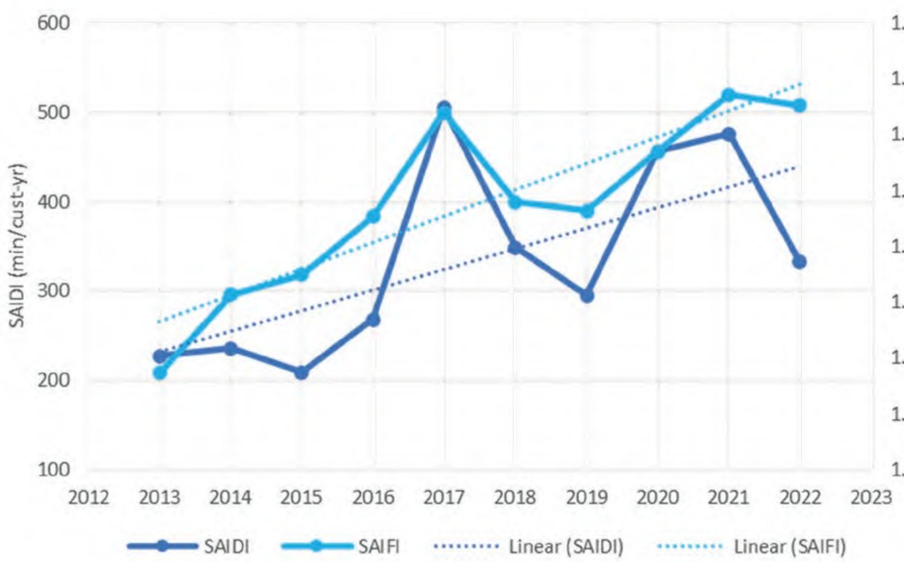


Figure 3
U.S. Reliability Indices with Major Events (IEEE)³



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SOP are a distribution application of flexible alternate current transmission systems (FACTS), which are a family of power electronics devices that allow controlling transmission and distribution line voltages, currents, and power flows.

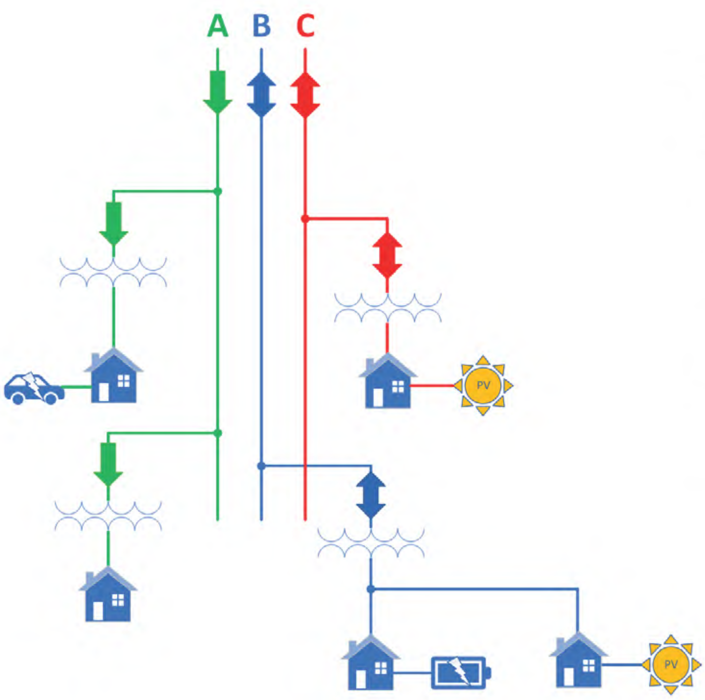
Addressing these challenges requires modernizing distribution systems to enable real-time operation, predictive analytics, and advanced planning applications. This requires, among others, the deployment of advanced technologies, the upgrade of foundational infrastructure, the implementation of efficient processes, and the training and recruitment of workforce with new skillsets.

SOP benefits include continuous and dynamic power flow control between neighbor feeders and substations, deferral of investments in capacity increase, improved reliability and resilience, increased DER hosting capacity, and power and energy loss reduction.

Over the last two decades there has been significant deployment of advanced technologies, particularly in distribution systems, examples include:

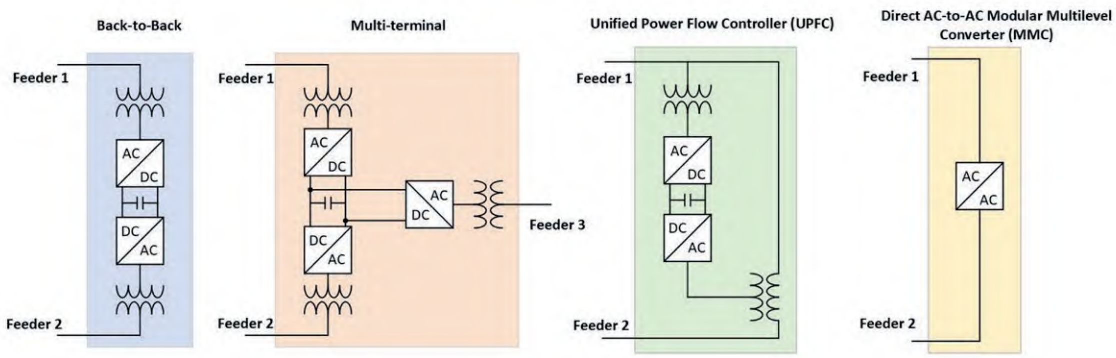
- Advanced metering infrastructure (AMI)
- Digital relays and intelligent grid devices (e.g., reclosers, capacitor banks, and voltage regulators with microprocessor-based controllers, voltage and current sensors, etc.)
- Distribution automation applications (e.g., fault location, isolation and service restoration – FLISR, volt-var optimization – VVO, etc.)
- Telecommunications infrastructure (e.g., optic fiber cable, remote terminal units, etc.)
- Advanced distribution management systems (ADMS) and DER management systems (DERMS)
- Smart inverters, microgrids and virtual power plants

Figure 4
Conceptual example of the increasing complexity to operate and plan distribution grids due to the adoption of DER and EVs



- Phase A supplies customers with traditional loads and electric vehicles (EV), current flows downstream
- Phase B supplies customers with battery energy storage systems (BESS) and photovoltaic (PV) distributed generation (DG)
  - Current may flow in the downstream (forward) or upstream (reverse) direction, depending on PV and BESS installed capacities, real-time output, and BESS operation mode (charging or discharging)
- Phase C supplies customer with PV, current may flow downstream (e.g., at night-time) or upstream (e.g., at daytime) depending on PV capacity
- In a high penetration scenario, each feeder and substation may supply hundreds or thousands of PV, BESS and EV. PV output can fluctuate significantly and rapidly due to cloud cover changes and some EV may operate in vehicle-to-grid (V2G) mode and inject power to the grid
  - Phase current and power flow magnitude and direction can change often, there may be violations of voltage and loading (planning) limits, voltages may fluctuate, imbalance can be an important problem, there may be total harmonic distortion (THD) issues, etc.

Figure 5
SOP Topologies



While significant progress has been made, the challenges introduced by the transformation of distribution feeders from largely passive and static radial lines into active and dynamic networks requires greater adoption of these technologies, along with the introduction of new technologies and alternative operation modes of distribution feeders.
In this regard, this article discusses the utilization of soft-open open points (SOP) to enable closed-loop operation of primary (medium-voltage) distribution feeders.
This concept can help mitigate the impacts caused by the adoption of variable renewable generation and electric vehicles (e.g., voltage fluctuations, voltage increase and decrease, asset overload, etc.) and allow for greater and more efficient utilization of existing asset capacity (e.g., lines and transformers). This can help increase DER and EV hosting capacity, optimize reserve capacity, and therefore, improve reliability and resilience. This includes deferral of capital investments for capacity expansion, which can address, to some extent, concerns regarding grid modernization affordability.

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It is worth noting that non-radial operation of distribution feeders is already utilized in some urban distribution applications (e.g., downtown areas of large cities) to attain premium reliability levels (e.g., spot networks, secondary networks, etc.). However, in suburban and rural areas, operation of distribution feeders is largely radial. Most urban and suburban feeders are natural candidates for implementation of closed-loop operation to mitigate voltage increase and fluctuation issues and facilitate DER integration, since their topology is generally meshed, and their operation is radial. This means that these feeders usually have multiple normally open points (NOP) with neighbor feeders that allow for reconfiguration and load transfers during outage management and restoration, and to address load growth needs. Generally, switches and reclosers with open status are deployed on those NOP to facilitate these activities.

SOP are a distribution application of flexible alternate current transmission systems (FACTS), which are a family of power electronics devices that allow controlling transmission and distribution line voltages, currents, and power flows. FACTS devices are increasingly being applied to distribution systems, for instance, static synchronous compensators (STATCOM) and low-voltage static var compensators (SVC) have been used to facilitate the integration of DER in distribution systems. SOP are deployed[4] in NOP of distribution feeders to control power flows between neighbor feeders and substations. SOP functions during normal operation include addressing asset overloads, voltage regulation (low/high voltage violations), reactive power compensation, and current/ voltage imbalance.

During abnormal conditions (e.g., during or after faults), SOP can isolate faults and support post fault supply restoration[5]. SOP benefits include continuous and dynamic power flow control between neighbor feeders and substations, deferral of investments in capacity increase (e.g., via peak shaving), improved reliability and resilience, increased DER hosting capacity, and power and energy loss reduction.

SOP topologies include a) two back-to-back voltage source converters (VSC) connected through a common DC link, b) multi-terminal VSC, c) distribution-class unified power flow controllers (UPFC)[6], and d) direct AC-to-AC modular multilevel converter (MMC)[7], as shown in Figure 5.

Figure 6 shows a conceptual example of an application of SOP to address distribution system issues. This figure shows two neighbor feeders with a planning limit of 4 MVA (this is the maximum amount of power that the feeder should deliver safely under normal operating conditions) and a NOP with a switch or recloser. Two scenarios are presented:

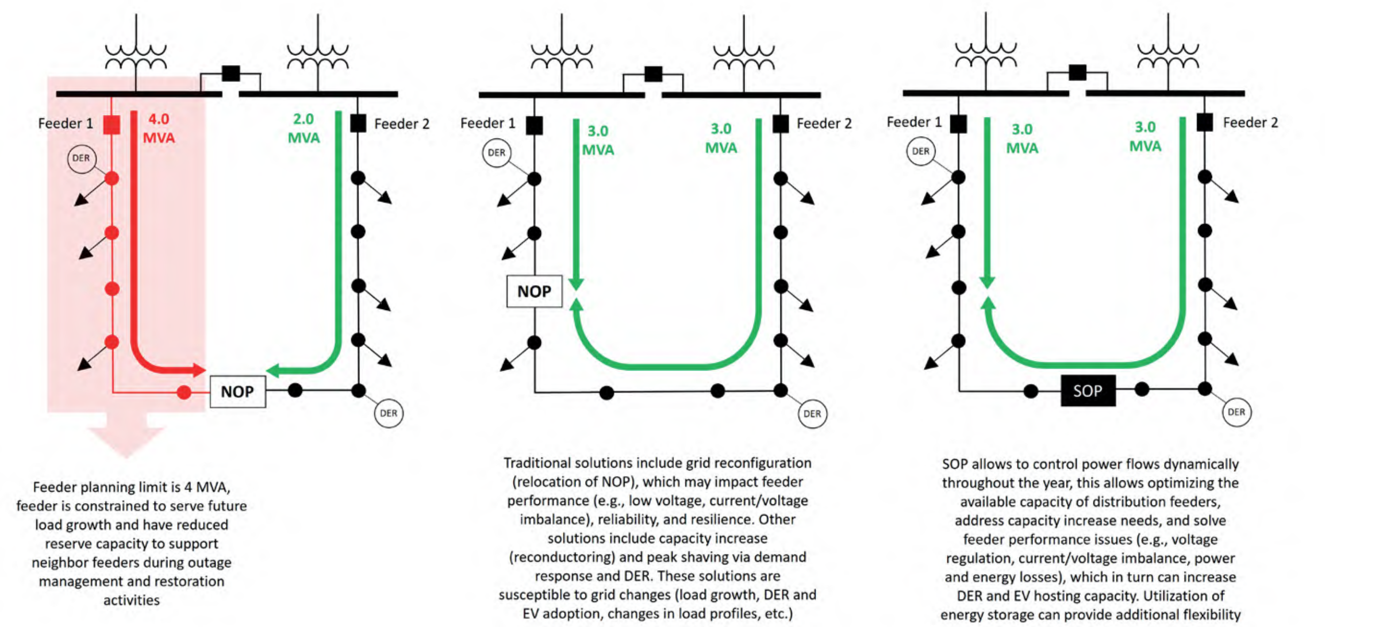
- In the first scenario (traditional), the annual peak demand served by the first feeder is twice that of the second feeder, this can be due to several factors, including the specific load profiles, load density, and number of customers served by each feeder. In this first scenario, there is no power flow through the NOP, since the switch or recloser is open, hence, the NOP serves as a boundary between both feeders. There is a need for capacity increase in this first feeder to serve future load growth and to host load transfers from the second feeder (reserve capacity) during outage management and restoration.

An alternative is to move the NOP to distribute the total peak load (6 MVA) evenly between both feeders (e.g., 3 MVA each), assuming both demands are coincident, i.e., they happen at the same time of the year. Moving the NOP may require changing the status of existing devices from open to close and vice versa, or the installing new devices on Feeder 1. NOP relocation would change feeder topologies (one feeder would be longer than the other), which could impact their reliability and resilience, and overall performance.

For instance, a longer feeder may have greater voltage drops, this could lead to temporary low voltage violations at feeder ends. Moreover, relocation of the NOP may impact current and voltage imbalance, which varies over the year, i.e., although current and voltage imbalance may be adequate during peak demand, it may exceed planning limits during other times of the year. Additionally, future changes in annual peak load (e.g., due to DER and/or electrification adoption) will change the optimal NOP location. In summary, the key challenge with this type of scenario is the largely static nature of NOP, which represents a limitation for the increasingly dynamic nature of distribution feeder power flows.

- In the second scenario (flexible), both feeders are operated as a closed loop and the SOP allows for controlling the power flow exchange between both feeders dynamically (like a valve in a hydraulic system). This capability can be used to balance demands, which solves the capacity issue in the first feeder. This can be implemented when needed, for instance, during a few hours or days every year (e.g., summer peak demands) or during outage management and restoration or temporary reconfiguration scenarios without the need to relocate the SOP. Moreover, SOP have the capability to perform this function for each individual phase of the feeder, which cannot be accomplished by a traditional NOP.

Figure 6
Example of Application of SOP for Closed-Looped Operation of Distribution Feeders



Examples of real-life deployments include the Active Response project by UK Power Networks (London, UK), which implemented SOP technologies on medium and low-voltage distribution feeders[8].

DER and EV adoption are leading to increasing impacts on radial feeders. These impacts can be alleviated by a combination of conventional and advanced technology solutions. As DER penetration increases, distribution engineers are left with less options, even advanced technology solutions are bounded by the physical limitations of existing radial feeders. Closed-loop operation enabled by SOP represents the next step in the evolution of the distribution system towards a highly efficient and flexible grid. Its advantages include improved voltages profiles, capacity utilization, reliability, and resilience, and more efficient operation. It also requires more complex protection systems, more robust equipment, and updated planning and operations philosophies. Since the technology required to overcome these issues is already available, the industry is encouraged to consider closed-loop operation as a viable alternative to achieve the goals set by the energy transition. A concerted effort is required to decrease technology costs of distribution-class FACTS devices, explore real-life applications, and enable greater adoption of these solutions.

Closed-loop operation enabled by SOP represents the next step in the evolution of the distribution system towards a highly efficient and flexible grid. Its advantages include improved voltages profiles, capacity utilization, reliability, and resilience, and more efficient operation. It also requires more complex protection systems, more robust equipment, and updated planning and operations philosophies.

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PERSPECTIVES

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The Case for Leadership and Collaboration

Transitioning to a net-zero economy hinges on the electrification of sectors like transportation, heating and industrial processes.

The U.S. and Canada collectively have a goal of net-zero emissions by 2050. This calls for comprehensive, strategic action from both the public and private sectors. Governments need to foster business investment, and stakeholders must form deep collaborations across all industries.

Transitioning to a net-zero economy hinges on the electrification of sectors like transportation, heating, and industrial processes. This will require a significant increase in clean electrical energy generation and a comprehensive overhaul of the electrical grid.

We Need Government Leadership

Businesses are reluctant to commit capital to long-term projects when future market conditions, regulatory landscapes, trade policies, and technological advancements are unpredictable. If governments establish clear, long-term policies—binding commitments to net-zero targets, carbon pricing mechanisms, and robust financial incentives—businesses become more confident in investing in clean energy and critical infrastructure.

Action from governments on clean electrical energy has often been fragmented and ineffective. Despite the need for a clean energy infrastructure, governments have mostly focused on small-scale, localized projects that address only parts of the broader strategy. This piecemeal approach does not adequately help us meet our emissions goals.

Photo: JFE Shoji Power

Currently, investments and policies only support elements like pilot projects, small-scale initiatives, and electric vehicle and battery development. These alone will not foster the massive increase in renewable energy integration we need, much less the electrification of other sectors.

Governments must be more proactive and strategic in directing investments to strategies that consider the entire electrical energy system. We need broader upgrades to the grid, long-term energy storage, and resilient supply chains.

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Without a holistic approach, we can miss critical components of the energy transition, such as large-scale grid modernization, smart grid technologies, and expanded infrastructure. We will not have the system to reliably deliver clean energy across North America and will fall short of our clean energy goals.

Expanding Clean Electrical Energy and Modernizing the Grid

Solar, wind, hydro, and other renewable sources should dominate our energy landscape. Beyond just adding capacity, we need a strategic, coordinated expansion. Governments must put the necessary incentives and regulatory frameworks in place to stimulate investment.

The current electrical grid, much of which was built decades ago, cannot handle the demands of a clean energy future. We need to significantly expand and modernize our electrical infra-structure, upgrade power lines and substations, and integrate advanced equipment like transformers, switchgear, and smart grid components. The new grid needs to support an electrified transportation industry, with a robust network of EV charging stations, to dramatically reduce carbon emissions.

The Importance of Strategic Collaboration

Governments cannot push the expansion and modernization of our electrical infrastructure alone. It requires deep, strategic collaboration between public and private sectors.

Businesses must find new ways to work together across supply chains, from raw material suppliers to parts producers and original equipment manufacturers (OEMs). Collaboration will foster innovation, maintain competitiveness, and reduce dependencies on foreign sources that undermine our progress.

Collaboration within USMCA

Like our business trade, the North American electrical grid is highly interconnected. It will take strong leadership and work between Canada and the U.S. to create a sustainable clean energy system for the future. By working together, we can innovate faster and lead the world in new energy technology. This will require having an open mind, for technical and business partnerships and cooperation, and for trade. Only by working together can we build the energy systems we need for the future, supported by political leaders who must create a trade framework that fosters innovation and speed of execution.

The Bottom Line

Moving to a clean energy economy is one of the most significant challenges and opportunities of our time. We can't just rely on technological breakthroughs and favourable market forces; we need strong government leadership to boost investment and

Photo: JFE Shoji Power

collaboration across the private sector. We must collectively focus on expanding clean electrical energy resources and modernizing our grid. This will forge the path to our goals of net-zero emissions by 2050 and a prosperous and sustainable future.

> **Businesses must find new ways to work together across supply chains, from raw material suppliers to parts producers and original equipment manufacturers (OEMs). Collaboration will foster innovation, maintain competitiveness, and reduce dependencies on foreign sources that undermine our progress.**

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Ron Harper is CEO and President of JFE Shoji Power Canada, a Burlington-based company that is one of the largest processors of electrical steel transformers in the world. JFE Shoji Power Canada is integral to the North American supply chain for electrical steels for power generation equipment, motors, power and distribution transformers, and specialized magnetic components. Ron has 35 years of experience in manufacturing, mostly in senior leadership positions in marketing, engineering, operations and general management. He has served on major industry and community Boards for the past fifteen years. He has been a member and Chairman of the Association for Manufacturing Excellence Executive Committee and AME Board of Directors, and a board member of The Centre for Skills Development and Training in Canada. He regularly advises with Next Generation Manufacturing on policies and initiatives for local government action, sustainability, and clean electrical energy.

Do We Really Need Another Show in the World of Power Transmission and Distribution? Yes! ...and here is Why:

Visitors will represent the full value chain all the way from the point of generation, all through the distribution network to the point of consumption be that in the factory, data centre or household.

Globally there is a lot of activity in the Power Transmission and Distribution sector by way of conferences and big energy industry events but very little that's focused specifically on the design, architecture, and technology for developing the next generation grids and electricity distribution networks.

Tony Robinson, a long-standing events innovator and leading exhibitions industry figure, is busy with the launch of a new show in Europe that will set things straight. As Tony says 'there are plenty of conferences in this sector and they have had considerable relevance for strategic discussions relating to the need for investment in new infrastructure to meet the next generation demands on electricity.

The strategy is now clear, the investment by governments and private/public partnerships is a given and the requirement to meet a net zero future in the face of huge capacity growth is well defined. So now it's time to design, build, specify and procure. It is "simply put", the biggest Bonanza moment in decades for specifiers, buyers and sellers of technology in the power industry to come together and make it happen'.

'What we are in the process of doing is giving the Power Transmission and Distribution industry its own 100% focused technology showcase exhibition. This is essential because there is just nothing like a show where professionals can go and see 100% of what's exhibited that is entirely relevant to them'.

Photo: Shutterstock

'Think of it like being in the world's best sweet shop where every booth is relevant to everybody there. From cables and substation equipment through to transformers, from smart metering, power management optimisation systems, weather and load forecasting and damage mitigation and advanced warning systems, everything will be on show for the engineering and technical people charged with building the next phase of power distribution networks.'

'Visitors will represent the full value chain all the way from the point of generation, all through the distribution network to the point of consumption be that in the factory, data centre or household.'

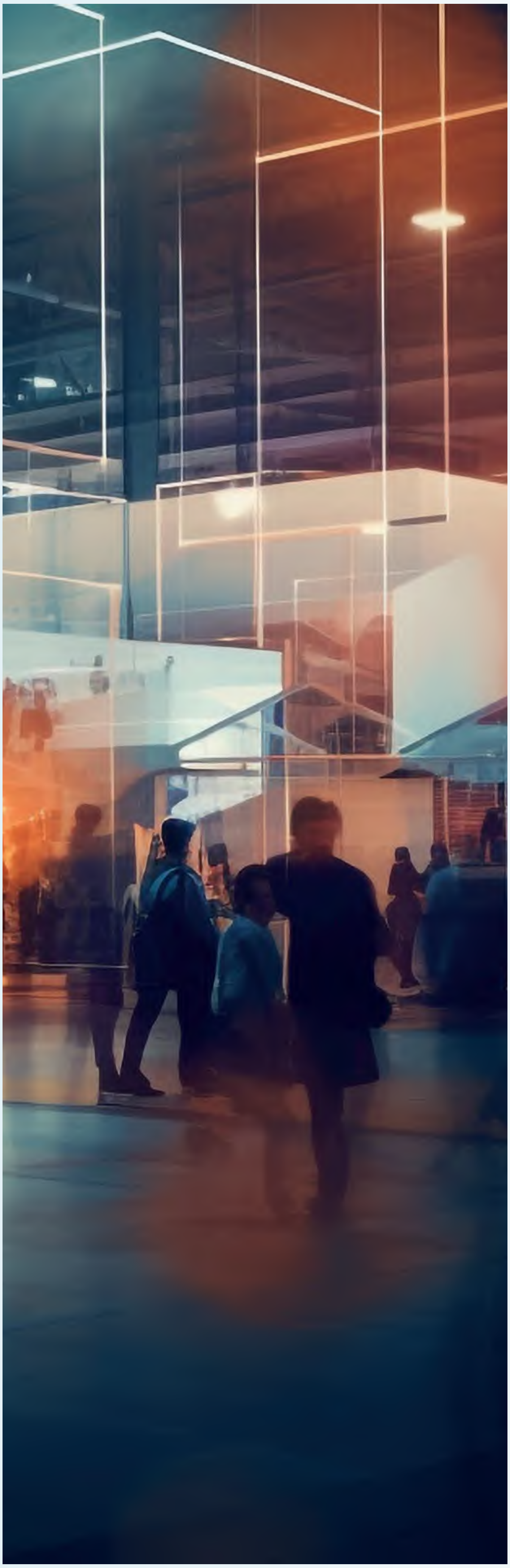
Tony has done this sort of thing for years and has transformed the way numerous industries now come together in sectors as diverse as tire design and manufacturing, aircraft interior design, and even in the weather forecasting world where previously such specific sectors were often caught up in generalist shows for rubber and plastic, aviation and the like. Now what he is doing is delivering us a truly focused exhibition for our industry.

What we are in the process of doing is giving the Power Transmission and Distribution industry its own 100% focused technology showcase exhibition. This is essential because there is just nothing like a show where professionals can go and see 100% of what's exhibited that is entirely relevant to them.

Open Technology Stages will be running within the show layout to enable exhibitors to explain and demo how their technologies can offer advantages. They expect around 3,000 to 4,000 visitors mostly from Europe, Middle East and North Africa and 200 exhibitors in a 3-day event spanning 220,000 sq ft (22,000 m^2 of space). It is taking place in Cologne, Germany which is in the most densely populated part of Germany and located in the busiest manufacturing corridor.

We welcome Power Transmission and Distribution Technology Expo to our industry event calendar for 2025.

Editorial Board
Power Systems Technology



Inside DuPont's European Technical Center: Pioneering Innovation in Transformer Insulation

by **Ante Prlic**
for **APC Media**

Insulation system based on Nomex® paper and pressboard for liquid-filled wind turbine transformer

DUPONT'S EUROPEAN TECHNICAL CENTER IN MEYRIN SERVES AS A HUB FOR INNOVATION, COLLABORATION, AND RIGOROUS TESTING. THE CENTER'S GLOBAL NETWORK, ADVANCED TESTING CAPABILITIES, AND FOCUS ON REAL-WORLD APPLICATIONS ENABLE DUPONT TO LEAD THE WAY IN DEVELOPING RELIABLE INSULATION SYSTEMS FOR THE POWER INDUSTRY.

In September 2024, Transformer Technology *visited DuPont's European Technical Center (ETC) in Meyrin, Switzerland, just outside Geneva and next to the world-renowned CERN research facility. The ETC plays a crucial role in DuPont's development of advanced insulation systems for transformers and motors. This visit highlighted the sophisticated testing capabilities and collaborative work driving innovation at the ETC.*

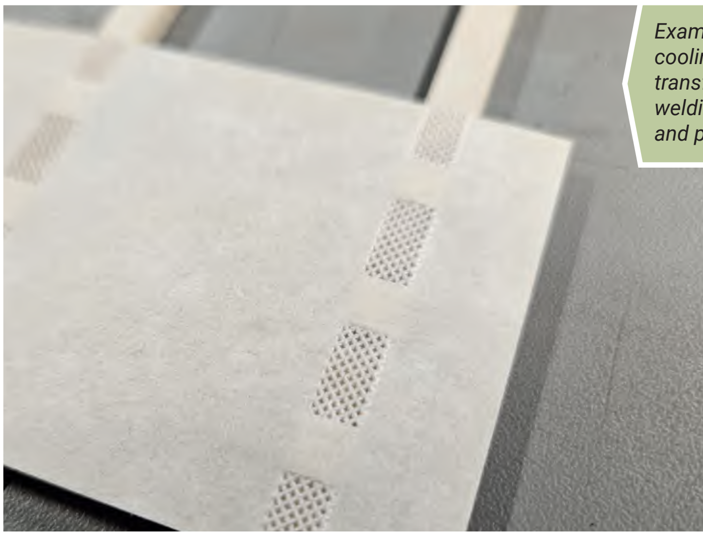
Our visit provided a comprehensive view of DuPont's approach to developing reliable, efficient insulation solutions through state-of-the-art testing methods. DuPont's team, including ***Jean-Claude Duart****, Technical Expert;* ***Radosław (Radek) Szewczyk****, Application Development Leader for Transformers, EMEA;* ***Bérénice Remy****, Application Development Leader for Nomex®;* ***Yannick Ittner****, Application Development Engineer;* ***Sébastien Tindillière****, Technical & Laboratory Support for Nomex® Energy Solutions, and shared their insights and expertise as they led us through the center.*

Global Collaboration and the Role of the ETC

DuPont's ETC is part of a global network of 22 technical centers that collaborate to push forward insulation technology. ***"The ETC operates under a uniform system across our labs in Europe, China, and the US,"*** explained Radek Szewczyk, during the introductory presentation. ***"This allows us to assign work based on specific lab capabilities, ensuring that we use the right resources for every test."***

This network enables DuPont to leverage a broad range of expertise. ***"We don't just test materials—we share knowledge and experiences across our labs worldwide,"*** added Jean-Claude Duart. ***"Whether we are validating a new insulation system or assessing the lifetime of materials, we benefit from a global pool of talent and technical resources."***

Radosław Szewczyk explaining the test for Comparative Tracking Index (CTI)



Example insulation parts: cooling duct for traction transformer; ultrasonic welding of Nomex® paper and pressboard

Photo: Ante Prlic

Example insulation parts: lead cable for power transformer with thick insulation build made of Nomex® crepe paper

Comprehensive Testing Capabilities for Advanced Insulation Systems

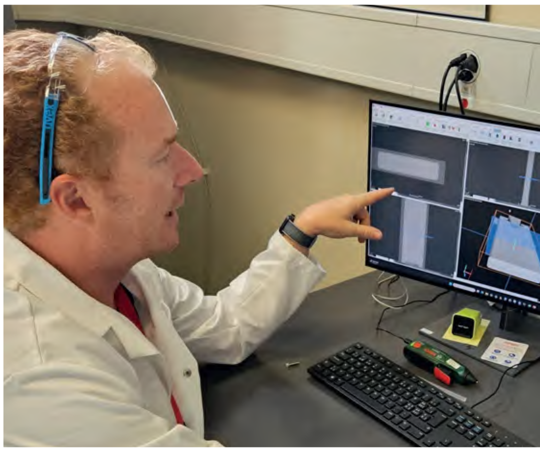
At the core of DuPont's approach is rigorous testing across the entire value chain, from base materials to finished windings of motors or transformers. ***"We test materials at every stage of their lifecycle,"*** noted Yannick Ittner. ***"From plain Nomex® paper to laminated products and finished conductors or coils, our goal is to ensure performance consistency throughout the product's lifespan."***
An important technology on display was the **pulse endurance machine**, used to apply high-frequency electrical stress on insulation materials. "***This machine simulates the electrical stress caused by modern power electronics, such as silicon carbide (SiC) components,"*** said Yannick. ***"We subject materials like Nomex® to high-voltage pulses at up to 28 kHz, combined with thermal stress. This allows us to evaluate how these materials degrade under real-world conditions, which is crucial for ensuring long-term reliability."***

In addition to electrical stress tests, Yannick emphasized the importance of combining multiple stress factors in testing. ***"The ability to simulate real operational conditions by combining electrical, thermal, and mechanical stresses is key to understanding how our insulation materials will perform in the field,"*** he explained.

Tomography and Mechanical Stress Testing: Ensuring Material Integrity

The non-destructive tomography equipment at the ETC provides an in-depth analysis of material integrity without cutting into samples. ***"Tomography allows us to see inside materials like pressboard or composite laminates without damaging them,"*** explained Sébastien Tindillière. ***"This is critical for detecting internal issues such as voids, improper glue distribution, or contamination that could compromise mechanical strength or dielectric properties."***

This level of precision, down to five microns, ensures that DuPont's materials meet the stringent quality standards required for critical applications. Sébastien demonstrated the tomography machine's ability to generate 3D models of materials, enabling detailed analysis of internal structures. ***"We can see exactly where the material might have air pockets or inadequate glue coverage, allowing us to correct these issues before the materials are put into use,"*** he said.

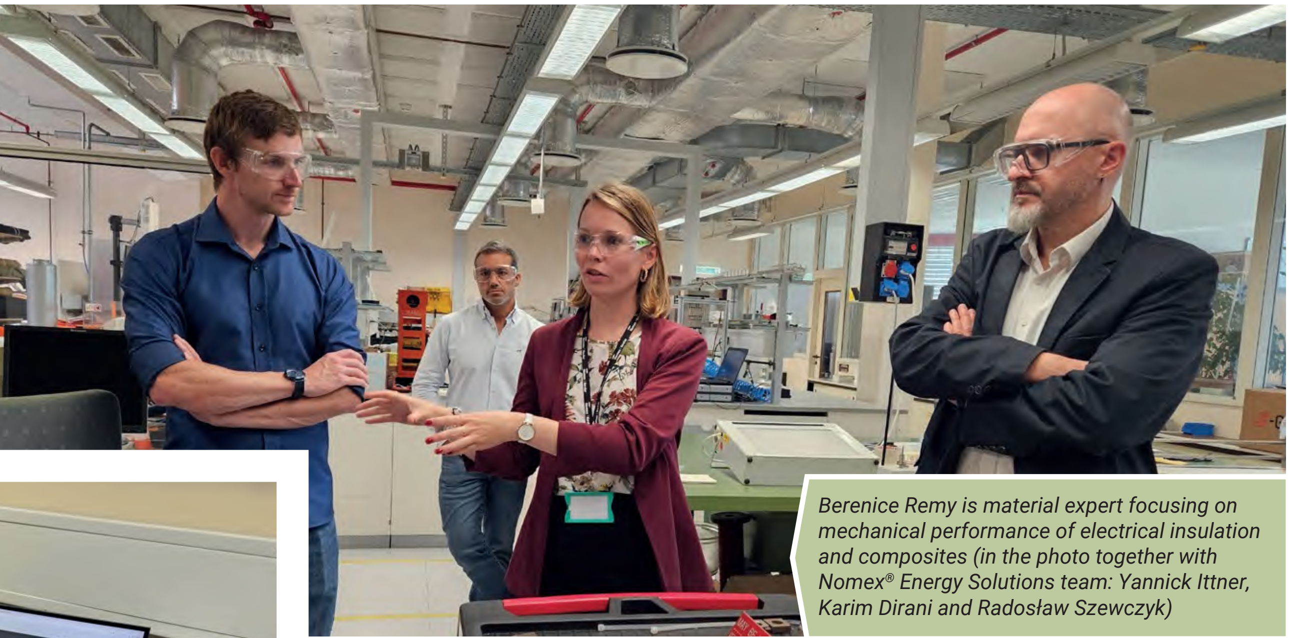


Following the tomography demonstration, Sébastien led us through the mechanical stress testing process. ***"We evaluate the flexural strength of materials by applying significant pressure to both laminated pressboard samples and solid Nomex® sheets,"*** he explained. ***"This helps us assess whether the materials can withstand the physical stresses they'll encounter in transformers, such as during short circuits or heavy operational loads."***

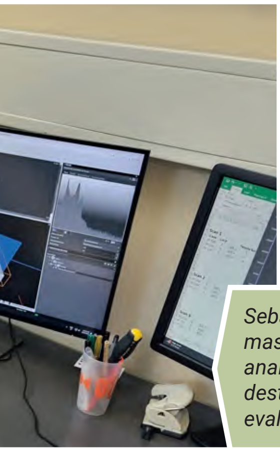
These mechanical stress tests simulate real-world forces, ensuring that materials like Nomex® maintain their structural integrity even under extreme conditions. The tests are conducted according to standardized methods to ensure consistent and reliable results.

But customized test programs can be developed, too, to address novel approaches to insulation system evaluations or to answer specific customer questions.

Photo: Ante Prlic



Berenice Remy is material expert focusing on mechanical performance of electrical insulation and composites (in the photo together with Nomex® Energy Solutions team: Yannick Ittner, Karim Dirani and Radosław Szewczyk)



Sebastien Tindilliere mastered tomography analysis for non-destructive material evaluation

Expanding Testing Expertise and Insights

During the demonstrations, additional insights were shared by Bérénice Remy, who emphasized the importance of maintaining consistency across testing and materials. ***"We ensure that all tests follow standardized procedures to provide data that is comparable across different projects and different labs,"*** she said. ***"This consistency is crucial for our customers, who rely on our materials to meet the highest performance standards, especially in demanding environments."***

Bérénice also highlighted DuPont's involvement in industry working groups, such as CIGRE, where their expertise helps shape future standards. ***"We contribute to standardization efforts through industry groups, helping to ensure that the materials we develop meet the evolving needs of the power industry,"*** she said. ***"This collaborative approach is vital to ensuring the highest level of reliability for transformers and other equipment."***

BY COMBINING CUTTING-EDGE TECHNOLOGY WITH A COMMITMENT TO COLLABORATION AND INDUSTRY LEADERSHIP, DUPONT'S ETC CONTINUES TO PUSH THE BOUNDARIES OF TRANSFORMER INSULATION, ENSURING THAT THE MATERIALS POWERING THE FUTURE ARE BUILT TO LAST.

Practical Innovations in Transformer Design for Renewable Energy

One of the key focuses of DuPont's work at the ETC is developing insulation systems for transformers used in renewable energy applications, such as wind turbines. ***"Nomex® allows us to design more compact and efficient transformers,"*** explained Radek. ***"By using Nomex® insulation, we can significantly reduce the size and weight of transformers, which is essential for applications where space is limited, like inside a wind turbine tower or nacelle."***

A model on display compared traditional cellulose-based transformer designs with those utilizing Nomex®, illustrating how the latter allows for smaller, compact designs. ***"With Nomex®, we can reduce the cooling ducts inside transformers, which not only saves space but also allows for more copper windings, improving efficiency,"*** added Radek. ***"This means we can design transformers that are more compact, easier to transport, and more cost-effective to operate. They also need less raw materials, which has direct impact on environmental footprint of the equipment."***

Supporting Industry with Comprehensive Testing and Collaboration

The ETC's role goes beyond just material testing. DuPont works closely with industry partners, helping them optimize insulation systems for specific applications. ***"We collaborate with manufacturers and utilities to ensure that our materials perform as expected in the field,"*** said Jean-Claude. ***"Our testing capabilities, from electrical stress simulations to material integrity assessments, provide the data needed to improve the reliability of transformers, motors, and other critical equipment."***

Radek also emphasized the importance of supporting customers through the entire product lifecycle. ***"We don't just provide the materials; we help our customers understand how these materials will behave under different conditions,"*** he said. ***"For instance, in the development of compact transformers for renewable energy applications, we work closely with manufacturers to ensure that our insulation systems meet the specific requirements of their designs. We also encourage testing of materials at the end of transformer life, or after equipment failures. Information on material condition may be very valuable for future designs and for better understanding of actual stresses in operating equipment."***

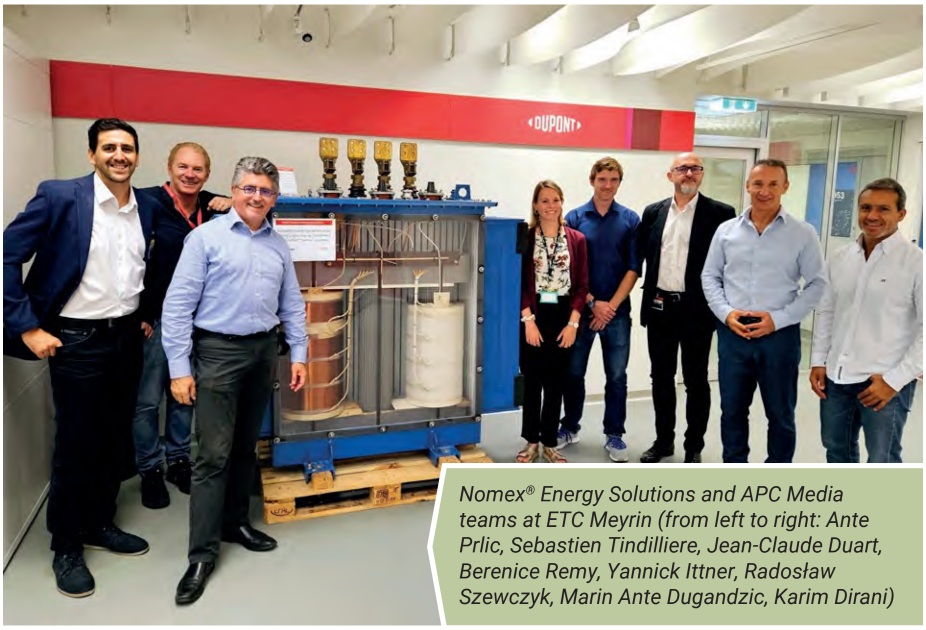
This collaborative approach extends to DuPont's partnerships with other companies, such as fluid and resin manufacturers. ***"Most of our materials are used in combination with other insulation products, so we work closely with our partners to ensure compatibility and optimized performance,"*** explained Bérénice. ***"This is particularly important in complex systems like liquid-filled transformers, where solid and fluid insulation must work together seamlessly."***

Conclusion: Advancing the Future of Transformer Insulation

DuPont's European Technical Center in Meyrin serves as a hub for innovation, collaboration, and rigorous testing. The center's global network, advanced testing capabilities, and focus on real-world applications enable DuPont to lead the way in developing reliable insulation systems for the power industry.

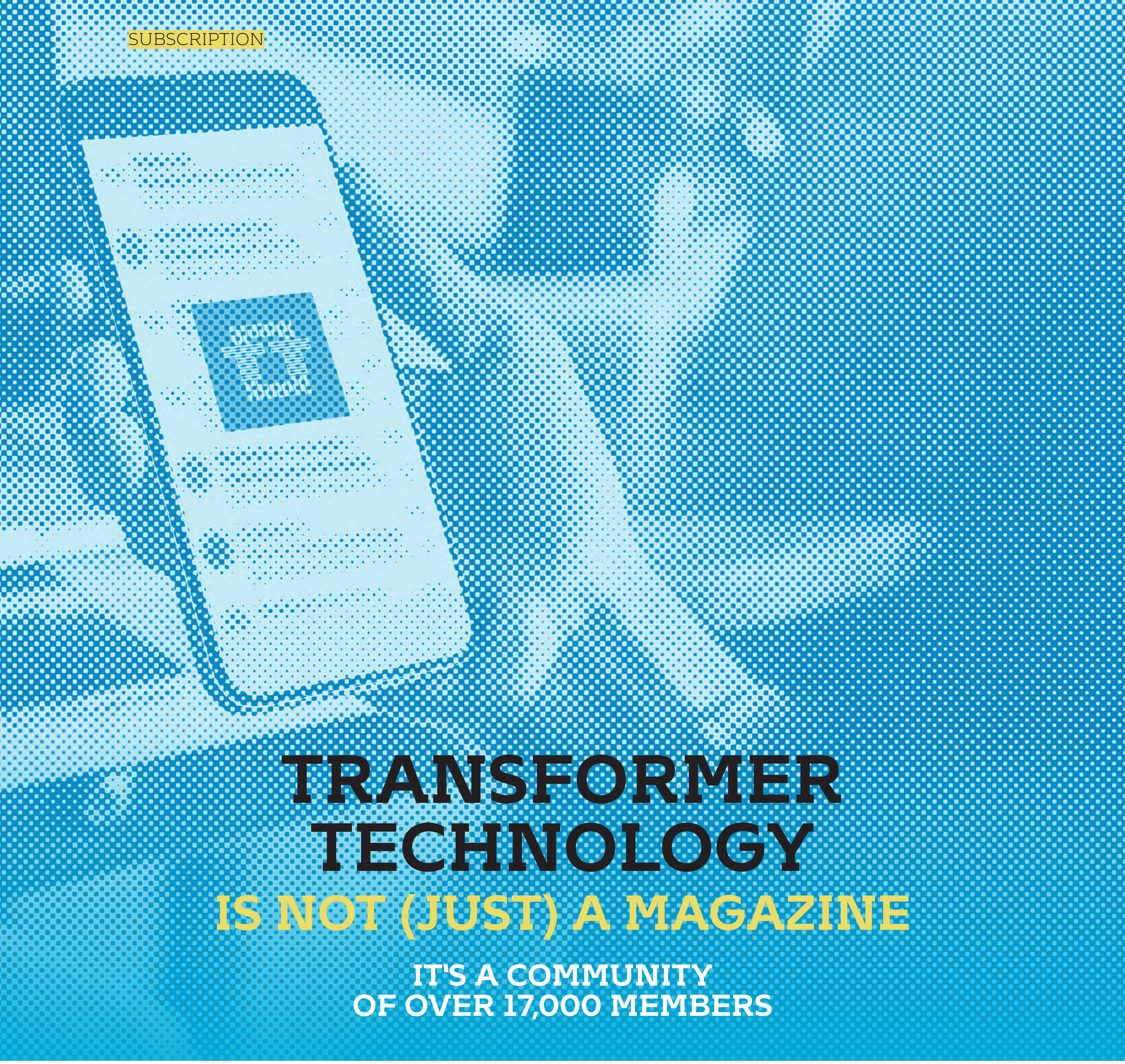
As Radek summarized, ***"Our goal here at the ETC is to ensure that materials like Nomex® not only meet today's standards but exceed tomorrow's demands. We are continuously working to provide solutions that empower the future with Nomex."***
By combining cutting-edge technology with a commitment to collaboration and industry leadership, DuPont's ETC continues to push the boundaries of transformer insulation, ensuring that the materials powering the future are built to last.
For more information please visit ES.NOMEX.com.

Ply-bond test on key spacer for power transformers (Nomex® pressboard)



Nomex® Energy Solutions and APC Media teams at ETC Meyrin (from left to right: Ante Prlic, Sebastien Tindilliere, Jean-Claude Duart, Berenice Remy, Yannick Ittner, Radosław Szewczyk, Marin Ante Dugandzic, Karim Dirani)

Photo: Ante Prlic



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Dynamic Thermal and Moisture Distribution in Transformers

by **Ali Al-Abadi**


Photo: Hitachi Power

THE RATE OF MOISTURE MIGRATION BETWEEN DIFFERENT INSULATION SYSTEMS DEPENDS ON THE DIFFUSION COEFFICIENT OF THE LIQUID AND THE PRESSBOARD AND IS THEREFORE A FUNCTION OF TEMPERATURE, INSULATION GEOMETRY AND PROPERTIES.

Ali Al-Abadi is a transformer expert in the fields of thermal performance, electrical insulation systems, moisture dynamics, sound and vibrations, electromagnetics, magnetic shielding, losses, and dynamic loading. Over the past years, he has been involved in the development of dynamic thermal and moisture distribution models in the insulation system of liquid-filled transformers, and the development of thermal performance models, development of analytical and numerical-based models to calculate sound levels for transformers and shunt reactors. Ali received his Ph.D. from Friedrich-Alexander University, Erlangen, Germany, in 2014. Following his doctorate, he worked as a research associate at the same university from 2014 to 2015, where he was managing collaborative industrial projects on wind energy, thermodynamics, fluid mechanics, aerodynamics, sound, and vibration. Ali started his career in the transformer field since 2015. In 2022, he joined Hitachi Power, Germany as a Business R&D expert and global team leader. Ali is an active member of standardization bodies and participates in several CIGRE working groups. He has authored and co-authored more than 50 articles on various topics related to transformers and power applications and reviewed numerous scientific and technical papers for international conferences and peer-reviewed journals. In 2024, Ali received the Best Technical Paper Award at the IEEE EIC Conference in the Transformers and Reactors session.

Introduction

The reliable and efficient operation of distribution transformers is essential to ensure the quality and continuity of power supply to consumers. One of the critical factors affecting the performance and lifetime of transformers is the thermal performance, which is determined by the cooling design. The cooling mechanism of a transformer passes through the insulation system (solid and liquid) through which the head is dissipated to the environment. The change in heat generated by the transformer during dynamic operation causes a change in temperature and therefore moisture migration between the liquid and solid insulators. The thermal dynamic behaviour depends on the load profile of the transformer and the environmental conditions, which cannot be easily estimated when evaluating power transformers in the field.

The rate of moisture migration between different insulation systems depends on the diffusion coefficient of the liquid and the pressboard and is therefore a function of temperature, insulation geometry and properties. When moisture exceeds acceptable limits in cellulose insulation, it affects the performance of pressboard liquid insulation systems in transformers by accelerating the ageing rate and reducing their dielectric and mechanical strength. Determining the moisture content over time in liquid and solid insulation supports the decision for liquid reconditioning and unit shutdown in time before paper insulation degradation causes failure.

Accurate determination of moisture in transformers during operation is an ongoing challenge due to the complicated mechanism of the moisture migration process and its dependence on many design and thermal parameters. Although drying procedures are usually applied at the manufacturing stage, the level of dryness must be maintained during operation to ensure a high level of dryness to delay deterioration of insulation strength and reductions in both dielectric strength and partial discharge susceptibility.

Moisture Saturation of Insulating Liquids

One of the main concerns and determining factors in transformer life is the rate of increase of moisture content during transformer operation. There are two main sources of moisture entering the liquid: the solid insulation and the atmosphere.
The liquid can absorb moisture from the atmosphere through weak seals, pressure differentials between the environment and the liquid, or during maintenance or repair.
These sources are manageable and can be controlled by quality measures. The challenge lies in the ageing of solid insulation, which inevitably forms water as it degrades. In addition, the drying process of the windings and active part could leave some moisture in thick wooden parts, which would migrate to the liquid during operation and spread to different solid insulation parts.

When dealing with different liquids, checking the water content in parts per million (ppm) does not provide consistent information because each type of liquid has its own moisture saturation (*MS*) curve, as shown in fig. 1.

Considering an operating point at 100°C with a water content of 20 ppm means relative saturations of about 0.4% for synthetic ester (*SE*), 0.64% for natural ester (*NE*) and 2.5% for mineral oil (*MO*). This difference in relative saturation shows that the water content limit for ester liquids can generally be higher than for mineral oil if safe dielectric operation is to be ensured.

In terms of temperature distribution inside a transformer, the relative saturation is expected to be different from one location to another in the whole tank volume. Assuming a 10 K difference between winding top liquid and tank top liquid with the same amount of water content results in a reduction of relative saturation at the hotspot area by about 15-20% at an operating point of 100°C. As

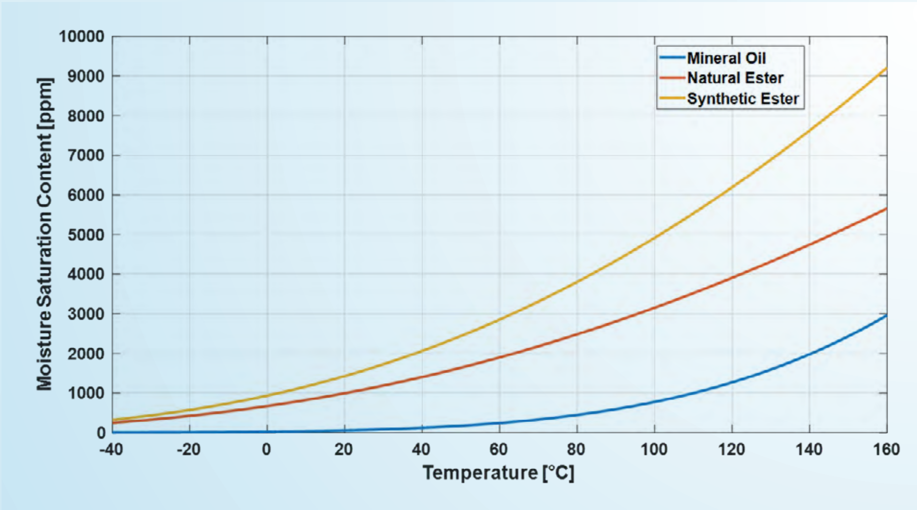


Figure 1. Comparison of the moisture saturation of different liquids versus temperature including the extreme cold range.

the synthetic ester has more space to absorb moisture, this deviation would be balanced by the moisture transfer from the solid insulation to liquid assuming that the transformer is hermetically sealed and the probability to exchange moisture with the ambient is low in the long term.

Relative Saturation Ratio for Transformer

From relative moisture saturation at the top liquid RS_L one can calculate the relative saturation of the liquid at the hotspot region RS_h by using reference temperatures of both. Similar calculation can be done for liquid in contact with pressboard barrier.

The moisture transfer between the ambient and the liquid could be ignored as this transfer needs longer time than the time required during testing the transformer in the test field. That means any change in water content in liquid would be assumed merely due to the transfer between liquid and solid insulation. If water content in liquid is measured offline in ppm, the relative saturation (*RS*) could be estimated in the liquid and the solid insulation using equation (1) and the curves of the moisture saturation content,

$$RS = \frac{C_W}{MS} 100$$

where, *RS* is the relative saturation [%], C_W is the water content [ppm] and *MS* is the moisture saturation content [ppm].

Along the same temperature scale, natural and synthetic ester liquids have higher moisture saturation compared to mineral oil. Therefore, the same relative saturation for both esters and mineral oil means different water content as the moisture saturation references are different at the same temperature. Water solubility of transformer liquids is temperature dependent, furthermore, it is directly affected by the liquid additives. Since, transformer commercial mineral oils typically have very little additive content compared to ester liquids, water solubility of different mineral oils is expected to be very similar.

The liquid moisture saturation curve can be expressed as,

$$MS = 10^{\left(-\frac{A}{T}+B\right)}$$

where *T* is the absolute temperature in *K*, *A* and *B* are the constants characterizing the liquid.

For a variable heat run temperature measurement on the case study transformer, the moisture saturation curves of *SE* in the hotspot region and the top liquid region are shown in fig. 2. It can be seen that the dynamic loading of the transformer causes the liquid saturation to change dynamically depending on the location and therefore the relative saturation is constantly changing.

The loading level affects the moisture saturation gap between the hotspot region and the top tank liquid region. The change in the saturation gap during dynamic loading indicates that there is dynamic water content transfer in the liquid volume, as the other moisture transfer mechanisms are slower to respond to water content diffusion between solid and liquid compared to the rate of dynamic loading.

The moisture diffusion mechanism can be found by decomposing the dynamic moisture saturation (*MS*),

$$MS(t) = g_{Sh} \cdot e^{\frac{-t}{\tau_{Sh}}} + MS_m \cdot e^{\frac{-t}{\tau_{MS}}}$$

where, *MS*(*t*) is the change in moisture saturation with time, g_{Sh} is the moisture gradient at hot spot region over mean moisture saturation of transformer liquid, τ_{Sh} is the moisture

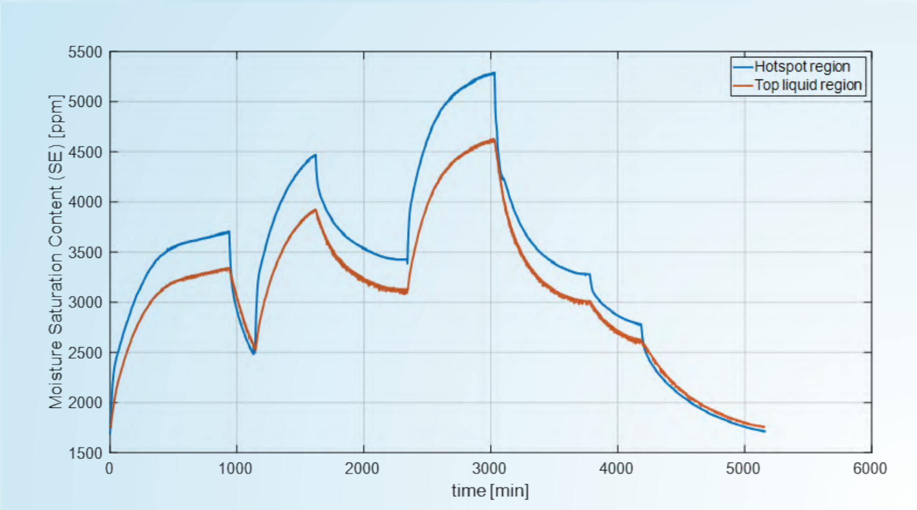


Figure 2. The dynamic moisture saturation curves of SE liquid-filled transformer at hotspot region and top yoke region.

Photo: Hitachi Power

saturation time constant at hotspot region, MS_m is the mean moisture saturation of the transformer liquid, and τ_{MS} is the time constant at mean moisture saturation. The analysis of Eq. (3) is presented in Table I, which shows the moisture diffusion from the inside to the outside of the winding liquid under the influence of the relatively rapid diffusion of the hotspot liquid τ_{Sh} to the tank liquid MS_m compared to the diffusion stabilization of the moisture inside transformer liquid volume τ_{MS}.

Observing the moisture saturation content at different temperatures of the liquid in different location inside the transformer tank would give understanding how the moisture migration within the liquid volume takes place during a transformer dynamic loading. If the water content of liquid is assumed to be the same everywhere due to liquid circulation, the relative moisture content at hotspot area (RS_h) can be calculated using the liquid saturation curve and the known relative saturation measured at top tank liquid sensor (RS_L) as follows:

$$RS_h = RS_L \cdot 10^{\left[A\cdot\left(\frac{1}{T_h}-\frac{1}{T_L}\right)\right]}$$

From which a relative saturation ratio (RSR) can be presented as follows:

$$RSR = \frac{RS_h}{RS_L} = 10^{\left[A\cdot\left(\frac{1}{T_h}-\frac{1}{T_L}\right)\right]}$$

Fig. 3 shows the hotspot gradient and the relative saturation ratio over the time range of the dynamic loading of the tested transformers filled with *SE* liquid. The *RSR* is inversely proportional to the hotspot gradient and indicates the negative hotspot gradient during extreme underloads or shutdowns. This indication is represented by an overshoot which causes the *RSR* to be greater than 1 when the hotspot gradient is negative, i.e. when the transformer has experienced extreme underload or shutdown.

With a reference liquid water content, which can be measured from a liquid sample taken on site before the transformer is switched on, relative liquid saturation can be observed at any operating temperature.

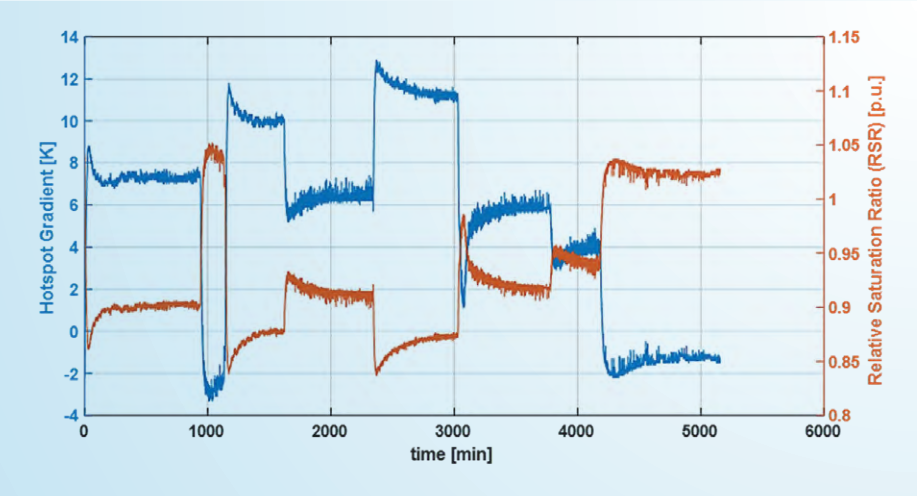


Figure 3. Hotspot gradient and the relative saturation ratio (RSR) over the time range of variable-stage dynamic loading of the case study transformer.

DIFFUSION TIME CONSTANT FOR PAPER-LIQUID AT HOTSPOT REGION

Location	g_{Sh} [ppm]	τ_{Sh} [min]	MS_m [ppm]	τ_{MS} [min]
HS	605.6	15.9	3133	798

Table 1. Diffusion time constant for paper-liquid at hotspot region

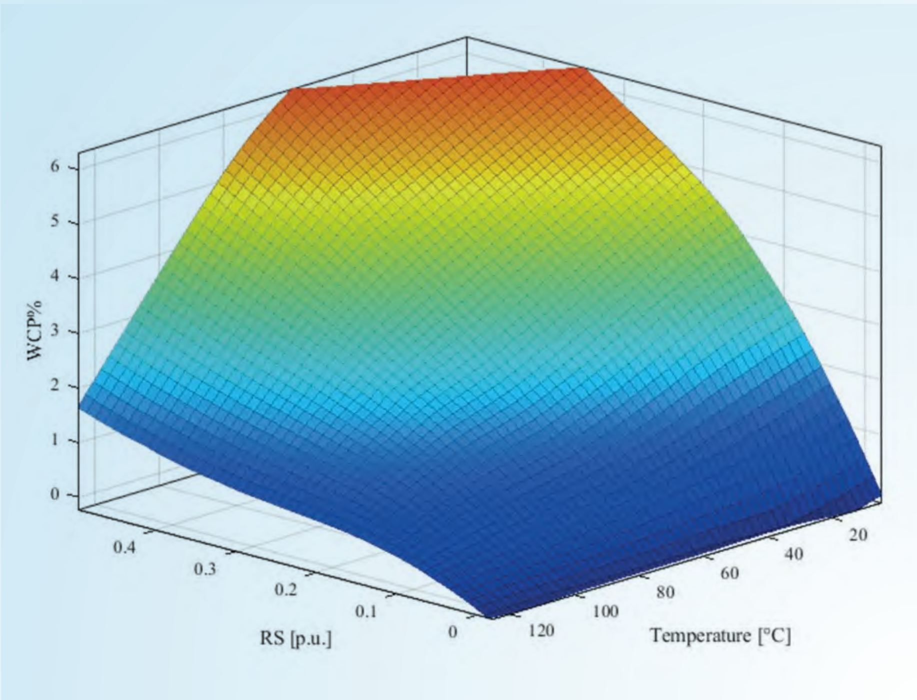


Figure 4. Equilibrium isothermal curves relating relative moisture in synthetic ester to water content in paper at different temperatures.

Using dynamic thermal modelling, *RSR* could be implemented and continuous monitoring of relative saturation in paper would be possible. For long shutdown periods, it is recommended to update the reference water content value in the liquid to have a more accurate input for the calculation of relative saturation in paper and liquid.

After calculating the relative saturation in the hot spot area, the water content in the paper can be calculated using equilibrium moisture isotherm curves. These curves have been described in a 3d surface as shown in fig. 4.

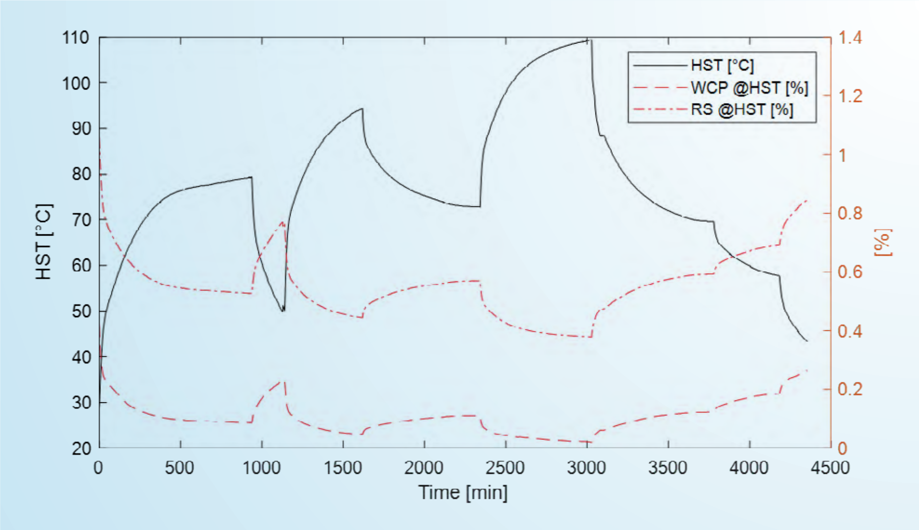


Figure 5. Variation of water content in paper (WCP) and relative moisture saturation in liquid at the hotspot region with temperature.

OBSERVING THE MOISTURE SATURATION CONTENT AT DIFFERENT TEMPERATURES OF THE LIQUID IN DIFFERENT LOCATION INSIDE THE TRANSFORMER TANK WOULD GIVE UNDERSTANDING HOW THE MOISTURE MIGRATION WITHIN THE LIQUID VOLUME TAKES PLACE DURING A TRANSFORMER DYNAMIC LOADING.

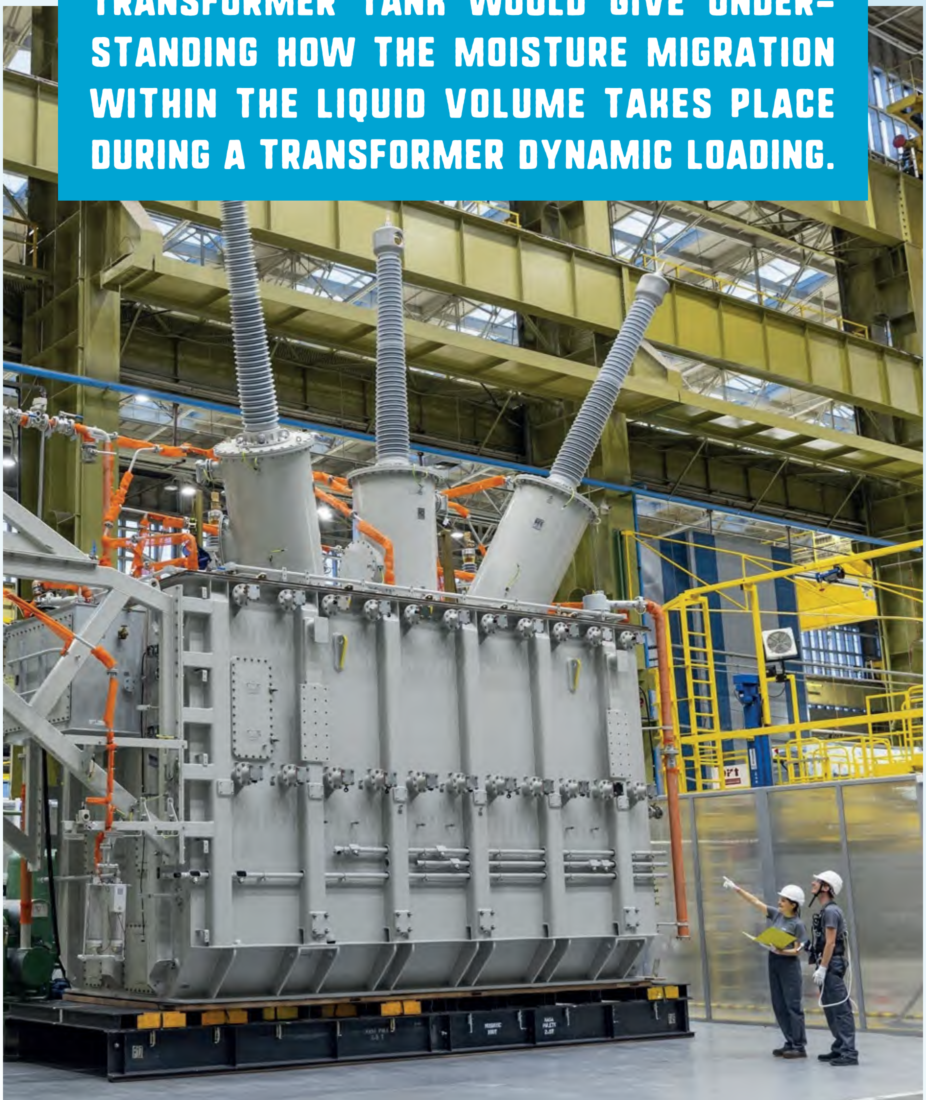


Photo: Hitachi Power

Thermal-Moisture Dynamic Modelling

The assessment of dynamic water content in paper at the hotspot region is implemented in the model according to the following procedure:

- Measuring the water content of the liquid in [ppm] on a sample taken from the case study transformer before heat run.
- Calculation moisture saturation at hotspot region using the measured temperature using *FOs*.
- Calculation of the relative saturation at hot spot region using water content in the liquid and the moisture saturation curve of fig. 1.
- With knowing hotspot temperature and relative saturation at the hotspot region, applying the equilibrium surface of fig. 9 leads to calculate water content in paper (*WCP*) that would apply under dynamic thermal loading condition shown in fig. 4.

Results of the *WCP* and *RS* are shown in fig. 5. It ought to mention that these calculations were based on assuming that the water content in the transformer remains the same due to liquid circulation.

References

References available upon request.

Gordon Atamanchuk

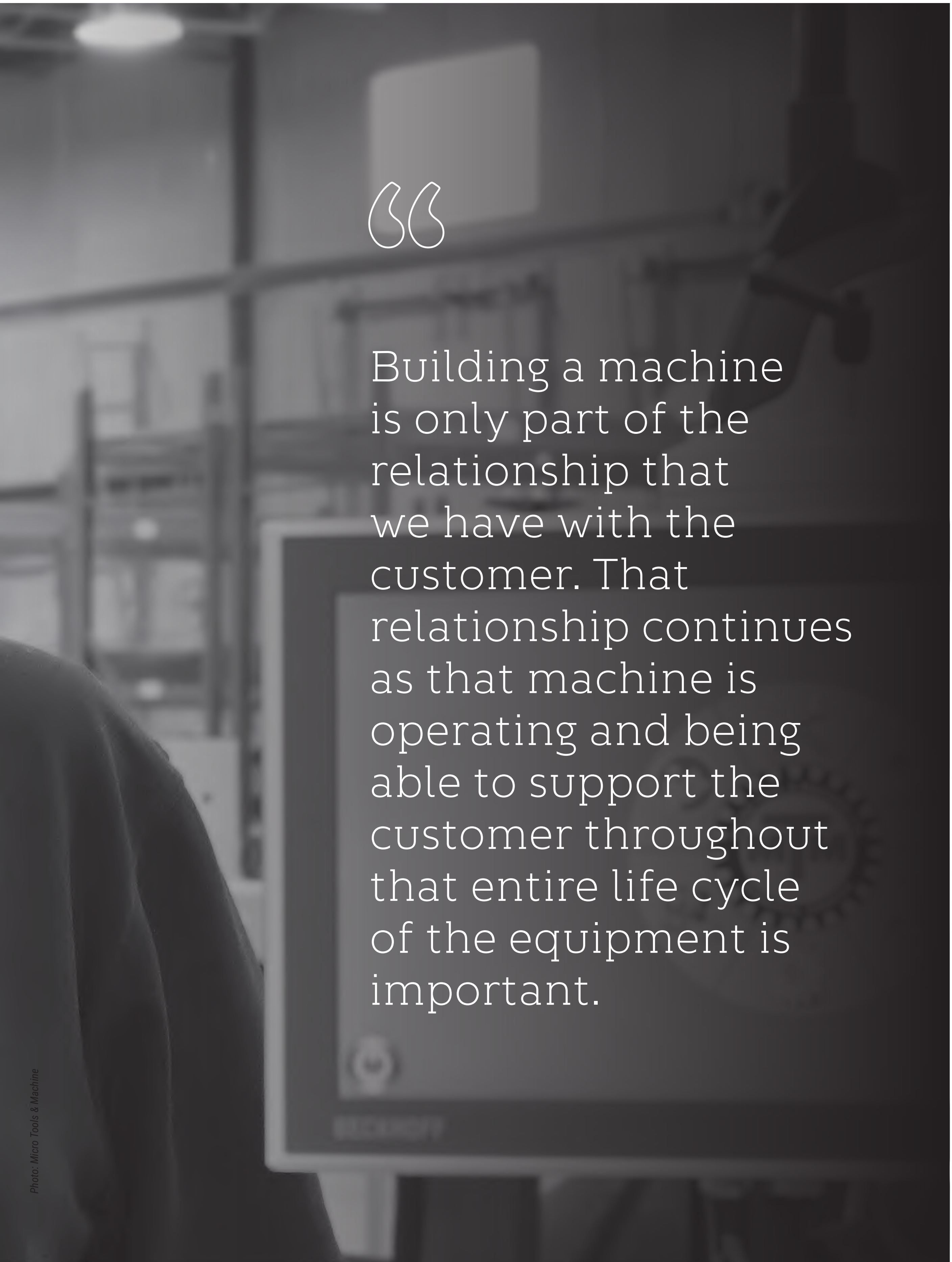


Photo: Micro Tools & Machine

"Building a machine is only part of the relationship that we have with the customer. That relationship continues as that machine is operating and being able to support the customer throughout that entire life cycle of the equipment is important.

Interview with **Gordon Atamanchuk**

President & CEO
of Micro Tool and Machine Ltd. (MTM)

My career has naturally progressed from machine development into product development, which has been an exciting transition. I studied mechanical engineering here in Winnipeg, and after graduating, I had the opportunity to work with companies like Caterpillar and General Electric. Through these roles, I gained valuable experience in product development, product testing, and field service.

Alan Ross: Gord, thank you for joining us.

Gordon Atamanchuk: Well, thank you Alan. It is a pleasure to be here.

AR You are the President of Micro Tools & Machine, but before we get to that, talk a little bit about your background and how you entered the industry.

GA My career has naturally progressed from machine development into product development, which has been an exciting transition. I studied mechanical engineering here in Winnipeg, and after graduating, I had the opportunity to work with companies like Caterpillar and General Electric. Through these roles, I gained valuable experience in product development, product testing, and field service. Each step has helped me build a strong foundation in taking concepts from design to real-world application, which is what ultimately drew me toward product development. I joined MTM in 2008 as an engineer, and I got the opportunity to work through various roles up to the position that I am now as President. Over that time, I was able to travel and visit transformer manufacturers all over the world and get involved in everything from design to business

Photo: Micro Tools & Machine

development, and eventually to where we are looking at all aspects of the business.

AR You said that you have had a number of different roles at MTM. Talk about the one that you think was most valuable to you right now, that is, a role you played at MTM that has given you the most insight into the industry.

GA Well, it's interesting because when I graduated from university, my first job was with Caterpillar, and that job was in product test and development. So, we took products that were being developed, and we tested them to ensure that they met specifications before being released to market. I learned a lot about what is needed from a situation of serviceability and functionality and what the final user needs in order to do their job correctly. I think that background was very valuable because it allowed me to look at the machines that we were designing and building for customers and make sure that those elements were integrated into the machine designs.

AR You joined MTM in 2008. Tell me a little bit about the history of the company. How did it get started?

GA Sure. It is interesting because we are in the middle of our 60th year right now. MTM has been around since 1964, always in Winnipeg, a Canadian-owned company. We started out manufacturing as a machine shop for the local industries here, so aerospace, agriculture, and heavy vehicle industries that are here. Over a few years, we started to build some custom machinery for a local transformer manufacturer here in Canada. And then that became the core business of what we did.

We have shipped equipment to about 48 countries around the world. Our primary focus, out of all those industries that we worked on, is the transformer business. And of that, we build primarily coil winding machines for distribution and medium-sized power transformer manufacturing. We also build cut-to-length lines for stacked core transformer designs, and we have a lot of tooling and fixtures that support the wound core market that exists as well. Our focus is on delivering a cost-effective machine to the market for which the customers can very quickly realize and see a return on their investment.

AR I love the word cost-effective. There's a lot of new products coming into the market, and they're not cost-effective.

Let's talk about the industry. When I say industry, I'm not talking about the power industry, I am talking about the transformer market because that is who you serve the most. There is now a demand curve for transformers that is skyrocketing because of the modernization of grids everywhere, because of their growth, and definitely because of data centers, especially AI data centers. They use tremendous amounts of power. Do you see the same thing, or are you concerned at all, that this new demand curve will not last?

GA We are downstream of the OEM, the transformer manufacturer,

Photo: Micro Tools & Machine

downstream of the grid you could say.
But we certainly have seen and experienced an increase in inquiries and orders related to winding machines and core cutting equipment. Much of it is centered around automation and the ability to improve productivity with the equipment. There is a lot of equipment out there, but it is more manual in its operation. I think people are looking for advantages to increase production, knowing that there is perhaps a constraint on manpower.

AR I have talked to several CEOs of transformer manufacturers, and they all have similar problems. They have greater demand than they are capable to supply. But the biggest problem they seem to all have is to get quality trades or crafts people, because it is still a manual operation, as you say. How hard is it to go from a manual operation to retrofit into an automated operation, especially for windings?

GA What we have tried to do with our machines' designs is balance that technology with what we call manual tasks. We have designed interfaces that are touch screen, very intuitive in their operation. If you grew up with an iPad or an iPhone, it follows the same logic and operation. I think it makes it easy for this new generation to adapt to the machines. There are opportunities to automate a lot of things on machines, but sometimes it's just easier to do it with a less automated solution, making it more cost-effective.

AR It seems as if the transformer OEM market is trying to go from a manual to an automated system because of labor shortages. Talk a little bit about the change, as in what happens on the floor when somebody uses your machine versus a manual process.

GA One of the easiest examples would be when looking at tensioning of wires, when doing a coil winding. Traditionally, those systems are controlled with mechanical systems, springs and pulleys to tension the wire, and the operator must make a judgment call on whether those wires in the winding are tight. Over the past few years, we have worked to develop automated systems to control that wire tensioning aspect of the machine. The operator can program in a desired tension value, and then that maintains it throughout the layer and throughout the whole coil design. And from an onboarding standpoint for a new operator, now they're following the prompts that are on the touch screen on what the next steps are for the coil design that they are doing. They do not have to focus on, say, tensioning which was a very subjective and a skill that was developed over time. What we have tried to do is focus on those types of elements that would help with the onboarding process and getting operators up to speed faster, making it repetitive and consistent.

AR The issue of tensioning, because it is subjective, can create problems that show up when we energize a transformer. Those are the areas that create the biggest problems, and it is extremely expensive to solve after the fact. Am I correct in saying "I'm giving you the reason why I buy your machine - if I don't solve it at a criticality point, the solution is extremely expensive."

GA Yes, that is correct. I think in manufacturing it is everybody's desire to be process-driven instead of people-driven. The features that we offer in our machines allow you to do that, to standardize in how you approach in this case, the coil winding, and then you get the repeatability between machines and operators and between shifts and so forth. And depending on what happens when energized, you might not be able to fix it.

AR Gord, with every OEM we know adding capacity or building new plant, how would you approach them about your solutions?

GA The conversation usually starts off more with what your needs and requirements are, and then I would go back into the answer to that solution. What I can tell you is that MTM has what we feel is a cost-effective solution for manufacturers that are in the transformer industry. We are focused on providing the right level of automation that would allow your team to increase productivity, standardize processes and help address some of their labor market needs.

AR Do you customize every solution? Is there one standard automated system and you just implement, or do you customize for everyone? I know your 60-year pedigree started with customized solutions as a machine shop, so has that ability persisted.

GA I would say that almost every project starts off with a standard machine design, but often it is customized to meet the customers' end requirements. So various numbers of conductors, whether that's a strip conductor or wires or different technologies for insulation, all those things can be modified and integrated into one machine design.
Each manufacturer has a slightly different focus. So, whether it's high-volume low-mix or

the opposite, we can tailor machines that would align to both of those types of manufacturing requirements.

AR Looking at the industry, when you go to bed at night, what worries you? What are the things you focus on that are in your control as you said?

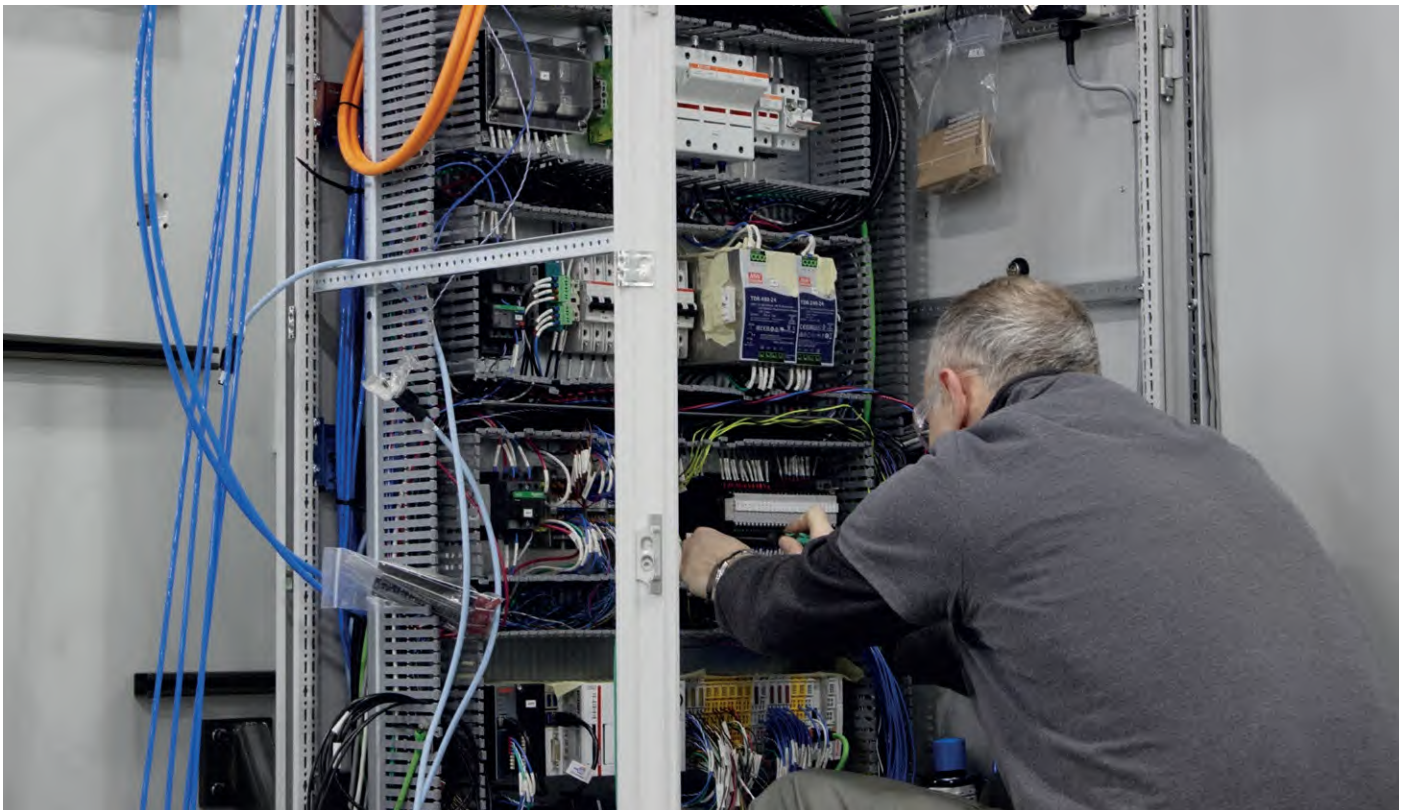
GA I have been trying hard to focus on the things that I can control and not so much on the things that are out of my control. We've moved into a new location. We've done a lot of things over the last year with a lot of thought and consideration where the market is going. I feel like we're really prepared for this hockey stick curve that you've indicated in your earlier statements. We see that demand coming from our customers, and we're up for the challenge to maintain what we consider the lead times to deliver that equipment. In terms of concerns or what keeps me up at night, I don't really think there is too many things. Obviously, the external noise that's going on, at any time in the world, is there, but you do your best to mitigate those items.

AR A 60-year-old company has a built-in pedigree about how you do what you do. What is the pedigree, the culture within MTM that you are trying to perpetuate or create?

GA I think that we realize that building a machine is only part of the relationship that we have with the customer. That relationship continues as that machine is operating and being able to support the customer throughout that entire life cycle of the equipment is important. So, what we are trying to instill with our employees and the culture here at MTM is that we want to provide high-quality machines, and then really look after the customer as we move forward and support them in their manufacturing.

Photo: Micro Tools & Machine

What MTM can offer is what we call a flexible machine deployment strategy. We can offer a machine that can easily cover a wide range of capacities with modifications that can happen after the machine is installed or can be configured at the time of purchase.



AR That is a great solution that ends well. Gord, you mentioned before this idea of flexible machines. Talk about this idea of the flexible machines that you are bringing into the marketplace.

GA Absolutely. In our previous conversation, we talked about what are some of the challenges which transformer manufacturers are potentially seeing. One of them is a changing market. Different KVA classes of transformers are in demand. And if the OEM is purchasing equipment to meet a specific solution, but the industry changes on them, do they have the right equipment? Lead times being what they are, I think these are all things that need to be considered at a given time.

What MTM can offer is what we call a flexible machine deployment strategy. We can offer a machine that can easily cover a wide range of capacities with modifications that can happen after the machine is installed or can be configured at the time of purchase. I guess a good example would be if we had a machine that was set up to do multiple coils, for distribution manufacturing, we could do two or three coils at a time. And then if there was a need to do larger KVA classes, the machine can be very easily configured to do a single coil, giving more flexibility to that machine.

Another example would be having machines that are what we call combination machines that can do the low-voltage and high-voltage sections all on the same machine design. If you go from a situation of high-mix low-volume to the opposite, you can easily transition that machine to handle both types of scenarios with no modification in the field. This is an idea that I think gives the OEM or the transformer manufacturer the ability to use the machines to a larger range of product classes as things evolve over the years or months. We'll see how the industry goes.

AR Gord, talk a bit about deploying your technology.

GA We have a white paper on this topic. So, if there is anyone who is interested in knowing a little bit more about how we can deploy, not so much technology, but methodology for their application, and want to reach out, then we can certainly share that with them and go through that conversation.

AR Excellent. We greatly appreciate your time, Gord.

GA Thank you, Alan. It was a pleasure.

Photo: Micro Tools & Machine

The Undamped Nature of the Modern Power Distribution System

by **Seth Johnson**

DESPITE TECHNOLOGICAL ADVANCEMENTS THAT HAVE IMPROVED THE ENERGY EFFICIENCY OF CONNECTED LOADS, POWER CONSUMPTION IN COMMERCIAL AND INDUSTRIAL MARKETS HAS STEADILY INCREASED, WHICH IS ATTRIBUTED TO MANY FACTORS, WITH THE PRIMARY REASON BEING THE ELECTRIFICATION OF EVERYTHING.

Photo: Powerside

Power distribution systems have significantly evolved since their inception in the late 19th century. Their primary purpose was to provide lighting to homes and businesses. The first power distribution system was direct current (DC), later converted to alternating current (AC) due to transmission efficiency. This dates to the infamous "Battle of the Currents" between Thomas Edison and George Westinghouse. Who won? One could argue that the battle is ongoing, but this article will focus on AC for power distribution.

The evolution of the power distribution system for incandescent lighting to industry electrification has posed many challenges that power systems engineers continue to navigate carefully. Nearly everything used in the modern day is electrified. Electrification demands increased distribution capacity and significant integration challenges when looking at practical ways to generate and supply power to modern commercial, industrial, and residential consumers whose load profiles have drastically changed over the last 30 years.

IN 2023, RENEWABLE ENERGY RESOURCES IN THE UNITED STATES CONTRIBUTED TO 22.5% OF THE TOTAL POWER GENERATION[1]. NEARLY A QUARTER OF POWER GENERATION COMES FROM RENEWABLE RESOURCES, WHICH IS ONLY EXPECTED TO GROW.

Seth Johnson is President and General Manager of Powerside, a company that specializes in optimizing power quality for Utilities and C&I markets worldwide. He holds a bachelor's degree from the University of Minnesota—Twin Cities and is an established thought leader and industry expert.

Consumers' Modern Connected Load Profile

Despite technological advancements that have improved the energy efficiency of connected loads, power consumption in commercial and industrial markets has steadily increased, which is attributed to many factors, with the primary reason being the electrification of everything. In conjunction with this are the numerous advancements in power electronics used in most modern-day connected loads. For example, LED lighting is known for being more efficient than traditional incandescent and fluorescent lights, but LED lights convert AC-to-DC through an LED driver. As with all non-linear loads, this conversion generates harmonic currents and injects them back into the AC power source. Harmonics are currents at multiples of the AC fundamental frequency, and a high percentage of most power system loads have this non-linear nature. Another example of a non-linear load is a motor controlled by a variable frequency drive (VFD). VFDs augment electric motors with rotational speed control but rely on AC-to-DC conversion. This process again introduces harmonic content back into the AC power feed. It can be definitively stated that most modern loads have become non-linear and inject harmonics back into the power distribution system.

Modern-day Power Generation

Power generation continues to change rapidly, with considerable initiatives aimed at decarbonization and green alternatives to traditional coal, natural gas, and nuclear power generation. Most notably, these initiatives target renewable power generation via wind, solar, and energy storage. In 2023, renewable energy resources in the United States contributed to 22.5% of the total power generation[1]. Nearly a quarter of power generation comes from renewable resources, which is only expected to grow.

Traditional power generation focuses on large rotating generators to

[1] *Lucía Fernández, Renewable Energy in the U.S. – statistics & facts*

produce high-inertia three-phase power transmitted and distributed across large areas, referred to as centralized power generation. This generation method is tried and true, and the foundation of our power system infrastructure. In today's modern approach to power generation, we are utilizing solar arrays and wind power at a massive scale to power distribution grids worldwide. These power generation assets are referred to as decentralized or distributed power generation, which involves many contributors to the power distribution system infrastructure.

Many renewable energy sources naturally generate DC power, which must be fed through inverters to bring power back to the AC power distribution system. Large-scale renewables require a host of inverters to generate the AC waveforms, which are then coupled back to the power distribution system. Like LED lighting or VFDs, the process of converting DC-to-AC, or AC-to-DC, relies on power electronics that create harmonic currents, which then get injected back into the power distribution system. Unfortunately, now we have a harmonic source for both consumption and power generation.

Resonance and Harmonics

Capacitance and inductance are key elements of the AC power distribution system. Capacitors maintain voltage and power factor, release capacity, and reduce losses. There are several ways capacitors are utilized, from substation to grid edge, and control methods match the tasks for which the capacitors are used. In many cases, these capacitors are fixed-on or controlled by a switching mechanism. Inductance presents itself in power distribution systems in conventional generation, overhead lines, cables, voltage regulators, and transformers. While each of these is not purely an inductor, they inherently have inductive reactance while being the most deployed assets in the power distribution system.

Resonance occurs in an electrical system when both inductance and capacitance are equal and in a shunt arrangement. The resonant point depends on the system and the location, but every AC power system has a resonance point. Historically, this resonant point had little consequence regardless of where it was in frequency. With the traditional power system relying on linear loads and power generation (lacking significant harmonic currents), the risk of exciting a resonance condition was minimal. However, in the modern power distribution system, this has changed significantly. Resonance conditions are excited regularly and intermittently depending upon the connection arrangements of power generation sources, capacitors, transformers, overhead lines, feeder cables, and many prolific non-linear loads. **Figure 1** shows an example of an actual 11th harmonic resonance on a power distribution system. When a resonance occurs, high harmonic current and voltage levels are observed at the resonant frequency. For a resonant point to be excited, there must be both a resonant network and a harmonic source at that frequency.

Power Quality Analyzers

From our foregoing discussion, it is evident that the modern power distribution system needs dedicated monitoring via power quality analyzers deployed throughout the entire power distribution system. These devices need deployment at the substation through to the grid edge, and they are immediately required at renewable power generation sites and large primary fed power consumers. However, employing these devices is just the beginning. A platform that allows these high-fidelity analyzers to stream data and provide data analytics at a fleet level is the future of intelligent and effectual monitoring. Utility power providers often rely on feeder protection relays or voltage regulators to provide power quality data.

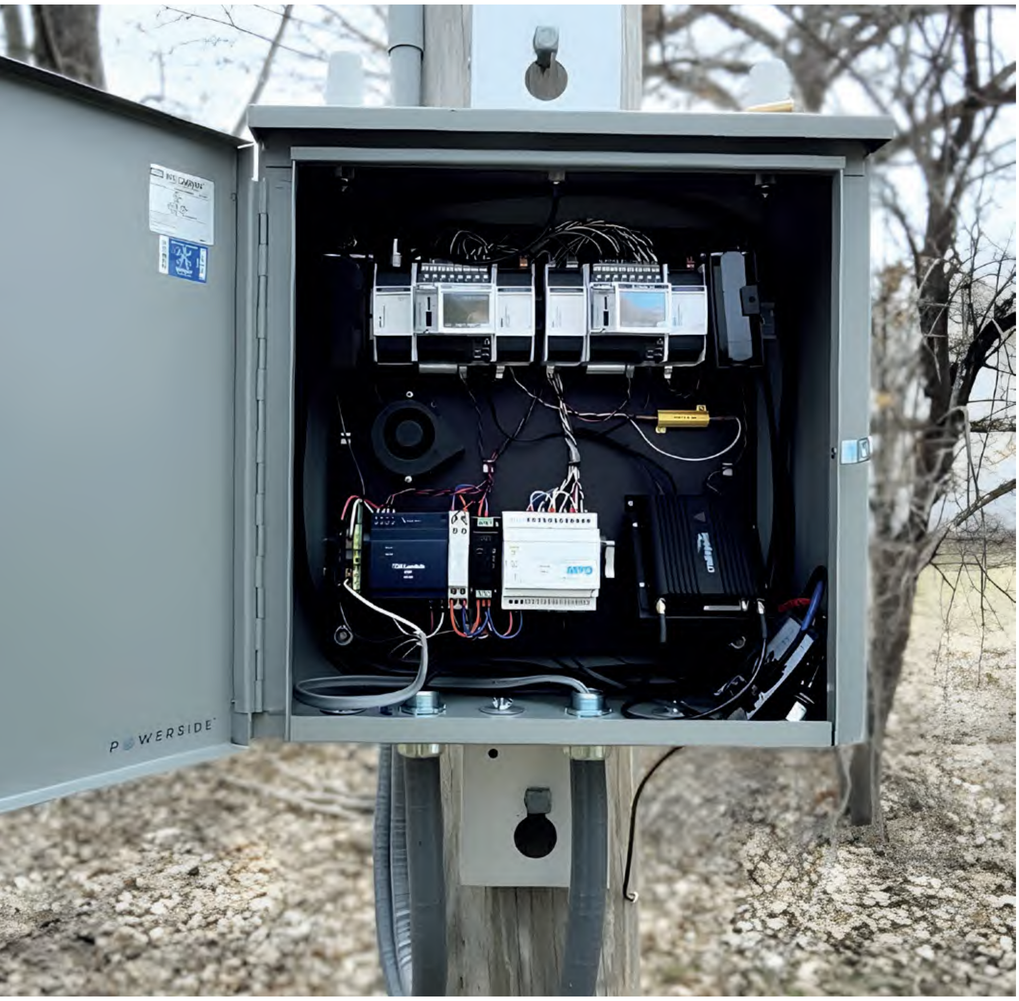


Photo: Powerside

While these devices have some power quality capabilities, it is not their primary function. Power quality analyzers must be able to deliver thousands of trending data points with event-triggered waveform capture, harmonics detection at high frequencies, and ultra-fast transient detection. With these functions, power anomalies such as resonance conditions can easily be detected and categorized through a fleet management platform.

Dampening the Modern Power Distribution System

The traditional power distribution system, in which load profiles and power generation have vastly evolved, is vulnerable to power quality issues at an unprecedented level. Resonance is a significant concern for power providers and distribution engineers who lack adequate field data, primarily due to inadequate sensors and the intermittent nature of many resonant conditions.

Levels of capacitance and inductance locate the resonant point of an electrical system, but this resonant point also changes when the system impedance changes. Due to the various power generation sources, this happens frequently in the modern power distribution system. Ultimately, the resonant point can be a moving target with little visibility.

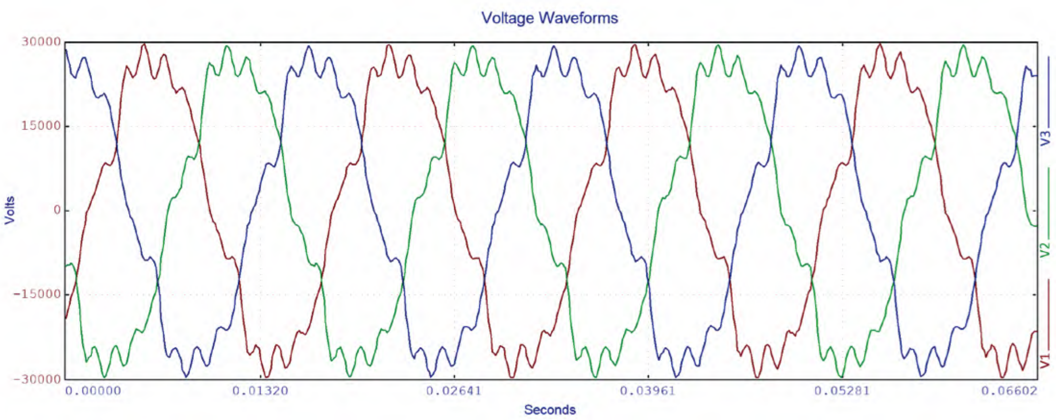


Figure 1.
11th harmonic resonance visible on voltage waveform.

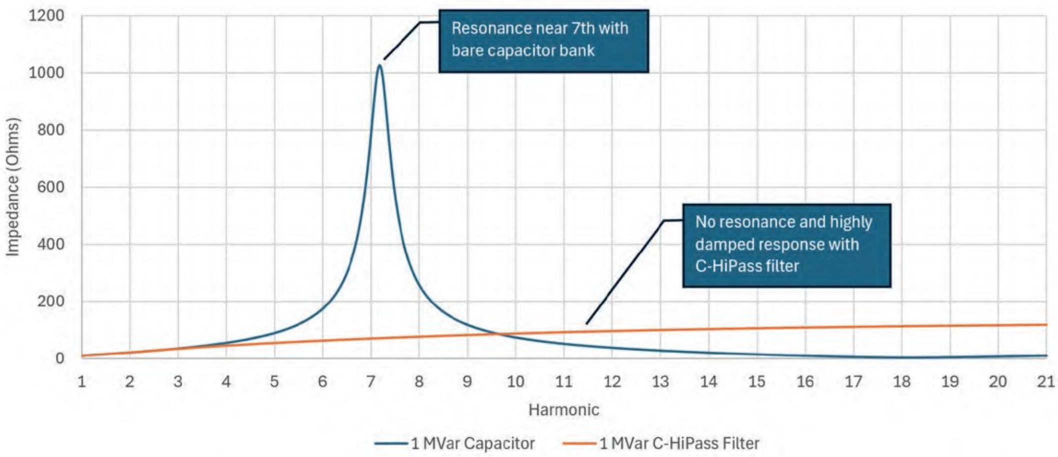


Figure 2.
Impedance vs. frequency for bare capacitor and C-HiPass Filter

One way to dampen an entire power distribution system is to avoid deploying capacitors and install filters instead. If appropriately sized, this will produce the same voltage stabilization and power factor correction that traditional capacitors provide. Moreover, a whole system deployment starting at the substation would be optimal. **Figure 2** shows the typical impedance scan of a system with a standard capacitor in an electrical network in blue and a C-HiPass Filter in orange.

IT IS EVIDENT THAT THE TRADITIONAL POWER DISTRIBUTION SYSTEM, IN WHICH LOAD PROFILES AND POWER GENERATION HAVE VASTLY EVOLVED, IS VULNERABLE TO POWER QUALITY ISSUES AT AN UNPRECEDENTED LEVEL. RESONANCE IS A SIGNIFICANT CONCERN FOR POWER PROVIDERS AND DISTRIBUTION ENGINEERS WHO LACK ADEQUATE FIELD DATA, PRIMARILY DUE TO INADEQUATE SENSORS AND THE INTERMITTENT NATURE OF MANY RESONANT CONDITIONS.

Photo: Shutterstock

Notice how the damped filter lacks resonance, preventing that condition from occurring. As a proposed network alternative, a large C-HiPass filter could be placed at the substation, and pole-mounted or pad-mounted capacitors could be replaced as more straightforward notch filters. Such a design would be specified to ideally dampen the power distribution system so that engineers would not have to consider resonant scenarios - the system is essentially protected for most conditions.

Of course, power providers still need their clients to abide by point-of-connection harmonic standards. However, if studies are done correctly at the engineering and design phase, deploying reactive power through filters can significantly limit the risk of harmonic-induced resonant events.

How Trump's Re-election is Shaping the Energy Transition and Grid Infrastructure Markets in the US

by **Saqib Saeed**
and **Hassan Zaheer**

It is safe to say that the latest United States election, compared to all previous ones, was the most anxiously followed by the energy sector, given the profound implications of the potential policy changes under the Trump administration. With Donald Trump elected as the president of the United States, stakeholders in the energy transition space are contemplating what is next.

There is a potential for several Biden-era policies and incentives like the IRA to be rolled back, leaving businesses and investors in the energy transition space worried about the future. But would the impact really be this negative? In this piece, we are examining the impact of the 2024 election result with a Republican win and Trump presidency on three specific markets: renewable energy, power grid equipment, and e-mobility. Let's get into these one by one.

Future of Renewable Energy in the US

Trump's skepticism around renewable energy is no secret. His recent campaign promises to scrap offshore wind projects and roll back subsidies under the IRA, which have been central to his proposed energy policy.

However, reversing these incentives and halting the country's renewable energy growth may not be straightforward for the new administration. For instance, President Biden has made significant strides in advancing the renewable energy agenda, even in the final weeks leading up to the transition to the Trump administration. An example of that is his launching a review of some offshore wind projects via the Bureau of Ocean Energy Management. Trump's Energy department pick, Chris Wright, has also made rather positive or neutral statements about renewable energy more recently during his senate confirmation hearing. He told the senate committee that (climate change) "is a challenging issue and the solution to climate change is to evolve our energy system...

Saqib Saeed is highly accomplished market research professional and a data storyteller in the international energy industry. With over a decade of experience in the field, he currently serves as the Chief Product Officer at PTR Inc. His expertise lies in the power grid and e-mobility equipment sectors. Saqib has overseen numerous global market research studies throughout his career and provided valuable insights to key decision-makers at various Fortune 500 companies. He is a member of the editorial board for Transformers Magazine and a member of the Advisory board of CWIEME Berlin and Middle East Energy. In addition to his market research career, Saqib has worked as an Electrical Engineer in the manufacturing sector.

Hassan Zaheer is the Managing Partner & COO at PTR Inc. based in Abu Dhabi, UAE. With more than a decade of experience in the energy transition space, Hassan advises various Fortune-500 and blue-chip clients in the electrical infrastructure sector to sustainably grow their businesses, both through custom consulting work, marketing support services and tailored research reports by PTR, helping their executive management and boards make data driven decisions. Hassan is also a Member of Advisory Board for CWIEME Berlin and MENA EV Show, part of the Executive Editorial Board of APC Media and an advisor to the educational non-profit Better Humans Academy. Hassan has a tech background with a Masters in Power Engineering from the Technical University of Munich (TUM) and a BS in Electrical Engineering from the Lahore University of Management Sciences (LUMS). Additionally, he is also an Alumni of Center for Digital Technology & Management (CDTM).

Are there things we can do, such as investments together through the Department of Energy, to accelerate the development of new energy technologies that are really the only pathway to address climate change? Absolutely...Energy and climate is a global problem...I think President Trump is firmly aligned with that position as well." He, however, also gave a pro-fossil fuel statement, mentioning that they have "fallen out of fashion and out of favor… there's been less interest to invest in it… I don't share those aversions. I'm all about new technology to improve energy sources across the board". This indicates a rather neutral stance might be the case as the new administration takes hold.

Photo: Shutterstock

Most importantly, the US renewables market today is very different from that of Trump's previous presidency. Over the last few years, renewables have become an important part of the US energy mix, accounting for more than 20% of the electricity generation (in 2023), according to the US Energy Information Administration, with wind and solar accounting for close to 15%. Renewables will continue to enjoy certain state-level support, especially in the case of onshore wind. So even though there would be changes to the renewables policy under the new administration, the complete rollback of IRA incentives is highly unlikely. Most of the incentives and investments under the IRA have been going to Republican-held congressional districts, leading to new jobs and economic growth, which would be difficult for Trump to stop right away.

Considering all these factors in its favor, renewables adoption will continue in the US. However, offshore wind will face headwinds, and the projects will be at risk of delays due to the suspension of leasing and permitting of federal land until environmental and economic review.

PTR's research estimates that offshore wind capacity, previously expected to reach 30GW by 2030, could decline to 10GW under less supportive policies.

Impact on the Power Grid Equipment Market

For a long time, the US power grid equipment market has been driven by the increasing demand for electricity and renewable integration, leading to modernization and upgrade/replacement requirements of the existing aging infrastructure. Despite offshore wind adoption slowing down, we expect the demand for electrical equipment, including transformers and switchgear, to continue growing sustainably until the end of this decade. With increasing electricity demand from sectors like data centers due to AI growth and increasing need for upgradation or replacement projects to ensure reliability and security of supply, high single-digit growth in equipment demand is expected in the US market.

What would possibly change, however, is where this equipment is sourced from. For example, the US has historically relied on importing both power and distribution transformers to address the local demand. More than half of the power transformers and close to a quarter of distribution transformers installed every year in the US are imported. In the past, we have seen import duties being extended on large power transformers from South Korea as well as a ban on Chinese transformers driven by national security concerns about dependence on foreign-made equipment for secure electricity supply. These bans or a higher import duty are expected to continue in this term as well.

With this increasing push to manufacture products within the US, as well as recent supply chain disruptions causing a major supply-demand gap globally, several transformers manufacturers have announced plans to establish or expand production locally in the US. This is likely to continue or accelerate under the new administration, especially given the expected corporate tax rate cuts and decreased red tape for local manufacturing.

Photo: Shutterstock

List of Announced Transformers Production Capacity Expansions in the US

Company	Trafo. Type	Investment (M USD)	Location	Investment Year
Hitachi Energy	DTR	25	South Boston, Virginia	2024
Hitachi Energy	DTR	10	Jefferson City, Missouri	2022
Eaton	DTR	22	Waukesha	2023
Maddox Industrial	DTR	N.A.	Batavia, Ohio	2023
Cleveland-Cliffs	DTR	150	Weirton, West Virginia	2024
Central Moloney	DTR	50	Okaloosa County, Florida	2023
Central Moloney	DTR	20	Panama City Beach, Florida	2022
Prolec GE	DTR	28.5	Caddo Parish, Louisiana	2023
Westrafo	DTR	15	Trotwood, Ohio	2024
Hitachi Energy	PTR	37	South Boston, Virginia	2022
Siemens Energy	PTR	150	Charlotte, North Carolina	2024
Hyosung	PTR	50	Memphis	2024
HD Hyundai USA	PTR	15	Montgomery, Alabama	2024
Delta Star	PTR	30	Lynchburg, Virginia	2023
WEG	PTR	17	Missouri	2021

Table 1. List of Announced Transformers Production Capacity Expansions in the US. Source: PTR Inc.

Impact on the E-Mobility Sector

Perhaps the sector most affected by Trump's return to the White House would be e-mobility in the US. The adoption of EVs and the installation of EV charging infrastructure would slow down in the US under the new administration.

One of the central issues is Trump revoking federal tax incentives for EVs, including the widely used $7,500 consumer tax credit under IRA. This move would directly impact the much-debated topic of EV affordability and adoption rates. Additionally, if the incentives on the supply side are repealed, it can impact the manufacturers who are still reliant on subsidies to compete with internal combustion engine vehicles. While companies like Tesla, with their profitability and scaled production, may navigate these changes more effectively, other players could face significant challenges. The stakes are particularly high for EV manufacturers due to significant capital tied up in factory investments. As of September 2024, over $260 billion ***(source: Atlas Public Policy)*** has already been allocated to U.S.-based EV manufacturing projects, with 70% of that amount invested in factories currently under construction. For many OEMs, these facilities represent a long-term bet on federal and state-level support for EV adoption. Any policy reversals that dampen demand for EVs could leave this capital stranded, posing serious financial risks for manufacturers. Any unspent funds from the charging infrastructure benefits of up to $100K per business for installing EV chargers have also been frozen, which will delay the installation of new infrastructure.

> With increasing electricity demand from sectors like data centers due to AI growth and increasing need for upgradation or replacement projects to ensure reliability and security of supply, high single-digit growth in equipment demand is expected in the US market. What would possibly change, however, is where this equipment is sourced from.

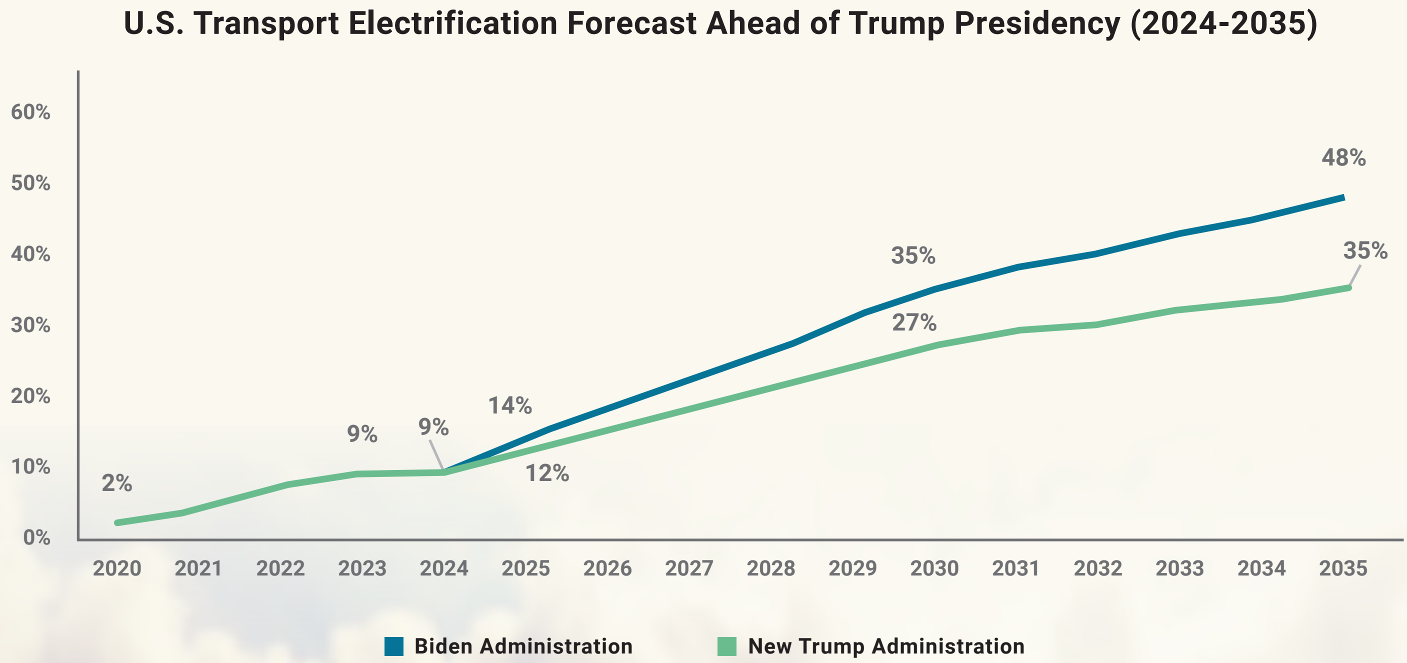


Figure 1. Market share scenarios of EVs (BEV & PHEV) in new light vehicle sales.
Source: PTR Inc.


Photo: Shutterstock

> The transition to a cleaner energy future is at a crossroads. Trump's policies could slow the pace of change, reshaping the EV and renewable energy industries in ways that will test the resilience of both established players and new entrants.

Trade policies are also expected to become more protectionist, with proposed tariffs on Chinese imports potentially doubling current rates. For the EV industry, this means accelerated duties on battery materials and components, potentially beginning in 2025 rather than the phased timeline ending in 2026 under Biden. Manufacturers relying on Chinese supply chains face rising costs, which could force a shift toward localized production. Meanwhile, Trump's intention to renegotiate the U.S.-Mexico-Canada Agreement (USMCA) adds another layer of complexity. While a full repeal of the agreement seems unlikely due to regional economic dependencies, the renegotiation could disrupt cross-border supply chains for automotive and battery manufacturing.

Given all these factors, PTR's projections suggest a slight slowdown in EV adoption by the end of this decade if these incentives are rolled back. While the previous forecast anticipated EV penetration to reach 35% by 2030, a more conservative estimate under Trump's policies could lower this to 27%. State-level regulations, such as California's Advanced Clean Cars Program, could also come under federal scrutiny. Should Trump repeal California's waiver allowing stricter state emissions standards, EV mandates across 12 other states could be weakened, further dampening growth.

> While a more fossil fuel-friendly federal government may create short-term challenges, long-term trends still favor the energy transition.

What Lies Ahead

The transition to a cleaner energy future is at a crossroads. Trump's policies could slow the pace of change, reshaping the EV and renewable energy industries in ways that will test the resilience of both established players and new entrants. For businesses operating in these sectors, adaptability will be critical as they navigate shifting regulations and evolving market dynamics. It would be critical to understand and leverage the state and local support for energy transition to navigate any policy headwinds from US federal policies.

While a more fossil fuel-friendly federal government may create short-term challenges, long-term trends still favor the energy transition. We believe that the companies that can successfully navigate and position themselves around these challenges by closely monitoring the policy developments and adapting their go to market strategies, accordingly, will continue to make progress and emerge stronger.

As a market research leader in the electrical assets and infrastructure space, PTR's focus remains on providing actionable insights to help stakeholders anticipate and respond to these changes.

About PTR

"With over a decade of experience in the Power Grid and New Energy sectors, PTR Inc. has evolved from a core market research firm into a comprehensive Strategic Growth Partner, empowering clients' transitions and growth in the energy landscape and E-mobility, particularly within the electrical infrastructure manufacturing space."

How Edge AI Helps Optimize EV Charging Locations: Real Results from Grid Operators

by **Binesh Kumar**

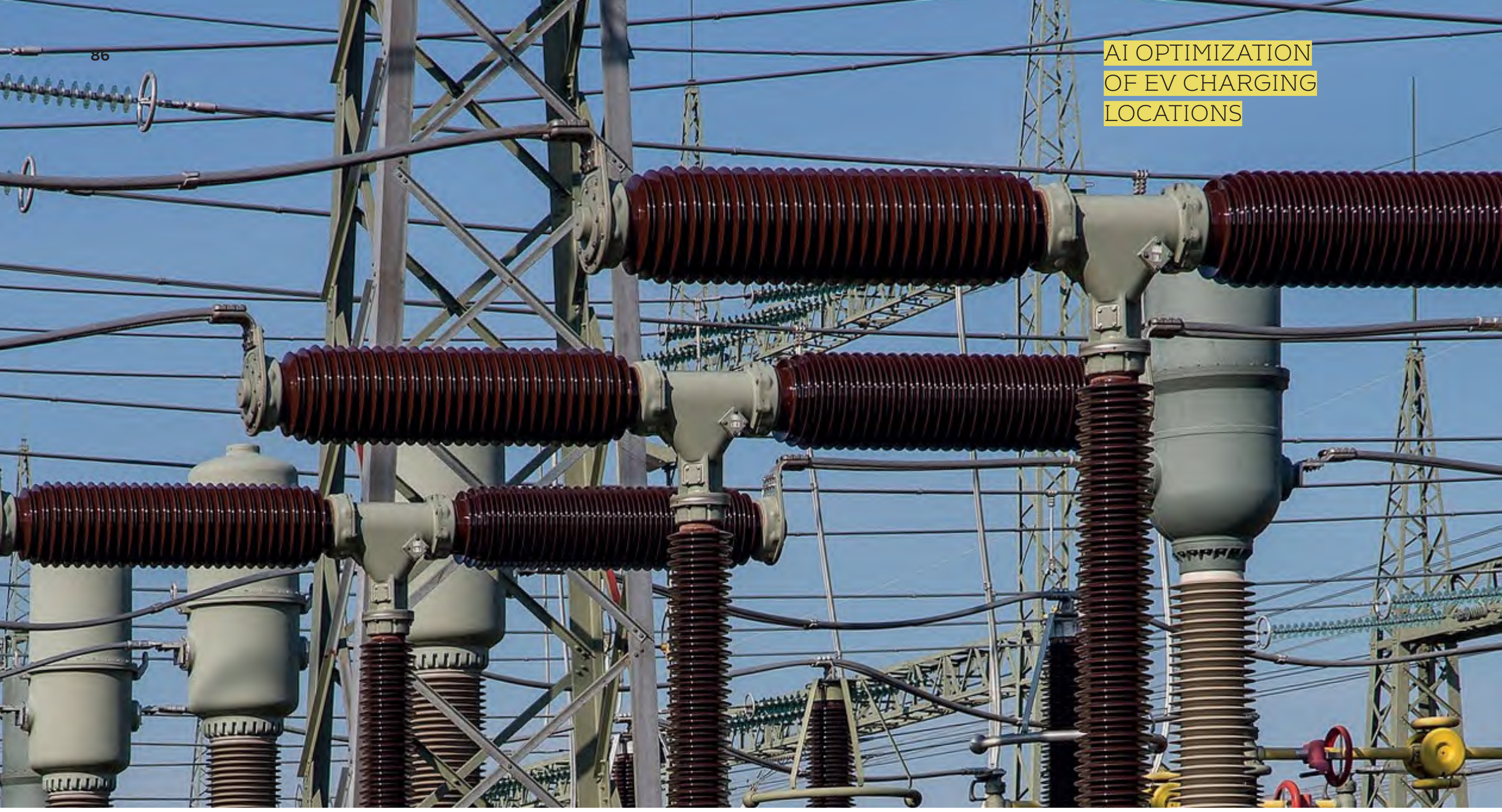
Grid operators now rely on Edge AI solutions to manage and optimize charging stations effectively. Studies from our research reveal that

Photo: AI-generated image

Binesh Kumar is a seasoned technology leader and engineering innovator specializing in the power and energy sector. As Director of Engineering at Atom Power Inc. in Charlotte, North Carolina, he has been at the forefront of advancing embedded systems and electrification technologies for over a decade. Binesh's expertise spans substation optimization, grid modernization, and the integration of cutting-edge technologies such as IoT, AI, and Edge Computing into power systems. An active IEEE Senior Member, Binesh serves in several leadership roles within IEEE, contributing to the advancement of technology standards and fostering industry-academic collaboration. His passion lies in solving complex challenges in energy management, driving sustainable solutions, and enabling the transition to a cleaner, electrified future. When not driving innovation, Binesh engages in thought leadership through writing and speaking engagements, sharing insights to empower the energy and engineering communities.

Europe's electric vehicle charging infrastructure has seen remarkable growth, with a 580% increase in public charging points since 2015. The continent now boasts over 330,000 charging points, with the Netherlands leading at 122,000 and Germany following with 65,000. EVs will likely make up almost 50% of all car sales by 2030, making the optimization of charging locations more crucial than ever before.

Edge AI implementation can optimize performance by 22% and lower assistance costs by 37%. The system's live alerts help reduce call-out costs by 47%, making EV charging more efficient and affordable.



Grid operators now rely on Edge AI solutions to manage and optimize charging stations effectively. Studies from our research reveal that Edge AI implementation can optimize performance by 22% and lower assistance costs by 37%. The system's live alerts help reduce call-out costs by 47%, making EV charging more efficient and affordable. Electricity needs will grow by 20% by 2030, so we'll look at how Edge AI transforms charging station management and prepares grid operators for electric mobility's future.

Understanding Edge AI's Role in EV Charging Infrastructure

Edge AI systems are the foundations of modern EV charging infrastructure. These systems process data right at charging stations and send only essential information to the cloud. This approach substantially improves operational efficiency and cuts data transfer costs.

Core components of Edge AI systems

Three key elements make up the foundation of Edge AI charging infrastructure:

- Advanced monitoring systems that track station performance and component health
- Predictive AI models that analyze operational patterns
- Live optimization algorithms that manage power distribution

These components create an intelligent charging ecosystem together. The ecosystem can predict maintenance needs and cut downtime. The system also keeps track of critical parameters like temperature, cable conditions, and battery status. This helps teams step in before failures happen.

Live data processing capabilities

Edge AI processes charging station data instantly. It looks at power consumption patterns and grid stability closely. Data processing happens right at the charging station level. This speeds up data collection and decision-making. The approach has showed remarkable efficiency gains. CUDA-accelerated GPU processing can optimize for a 500-EV parking lot in under 30 seconds.

Live capabilities go beyond basic processing. Particle swarm optimization algorithms calculate different charging schedules. They look at various factors like vehicle arrival times, departure schedules, energy demand patterns, and time-based electricity costs.

Integration with existing grid infrastructure

Edge AI works seamlessly with existing grid infrastructure to maintain stability and optimize power distribution. Edge computing helps control energy loads in real time, which helps keep the grid stable during emergencies. Smart edge nodes can balance charge schedules across multiple EVs without putting too much strain on local transformers.

The system manages loads in sophisticated ways. Research suggests that smart EV charging could reduce peak loads by 10-15%. Smart energy meters can quickly move power to high-demand spots while slowing down charging during peak times.

Edge AI systems improve grid stability and optimize energy use through advanced demand forecasting and autonomous load adjustments. This integration supports vehicle-to-grid technology and provides ancillary services that make modern energy grid operations stronger.

Optimizing charging station locations through AI Analytics

AI analytics is a vital tool that helps determine the best locations for EV charging stations. GM's data scientists showed this by using predictive analytics and geospatial algorithms to review EV traffic patterns in the United States.

Key location factors and data points

The selection of charging station locations depends on several critical factors:

- Traffic flow analysis and proximity metrics
- Population density and demographic data
- Grid infrastructure capacity
- Existing charging station distribution
- Local amenities and points of interest

These factors are the foundations of a mathematical optimization problem that weighs both economic and environmental costs. The original analysis uses data from existing infrastructure to identify gaps in coverage and areas where we just need more stations.

Demand prediction models

Advanced deep neural networks, specifically α2-LSTM models, have achieved remarkable accuracy in predicting charging demands. These models are shown compared to traditional LSTM networks 9.2% reduction in Root Mean Square Error. Categorical Boosting Regression models performed even better with the lowest mean absolute error of 0.0726 and root mean square error of 0.1059.

The demand prediction process works at a 15-minute time resolution to forecast charging requirements precisely. This detailed approach helps us understand peak usage patterns and optimize resource allocation.

Geographic optimization algorithms

Geographic optimization uses sophisticated algorithms based on finding potential locations for new charging stations (Voronoi diagrams). This numerical approach weighs proximity properties and existing infrastructure to determine optimal placement. Custom K-means clustering algorithms now include charging demand and energy consumption patterns that ended up improving how charging infrastructure is deployed strategically.

The optimization process handles both urban and non-urban areas through the H3 spatial grid system, which models spatial data accurately in areas with different population densities. This method works especially well when you have to minimize competition between stations while ensuring convenience for long-distance EV users.

Real-World Implementation Case Studies

Leading organizations now use Edge AI solutions to find the best EV charging locations. This has led to big improvements in how they work and cut costs.

Major utility deployment examples

Oxfordshire County Council leads the way with an advanced Edge AI system. They combine geospatial modeling with various data sources to place charging infrastructure better. The solution helps planners and charge point operators work together through AI-driven insights. It's worth mentioning that this system puts local communities first while making the most of infrastructure budgets.

The Royal Military College of Canada offers another interesting example. They created a smart solution that works out the best charging schedules for large parking lots in real time. Their system looks at

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when vehicles arrive, when they leave, and energy costs to figure out the best charging combinations. The results were impressive - their system could work out schedules for 500 vehicles in less than 30 seconds.

Measured performance improvements

Edge AI systems have brought some big, measurable improvements:

- Predictive maintenance optimization: 22% performance improvement.
- Assistance cost reduction: 37% decrease in maintenance expenses.
- Call-out cost reduction: 47% improvement in emergency response efficiency.

We used Edge AI at charging stations to process data locally, which meant less data needed to go to the cloud. This led to faster data collection and better security protocols.

ROI analysis and metrics

Edge AI brings clear financial benefits to EV charging infrastructure. Studies show that EV maintenance costs 40% lower than regular vehicles. The energy cost analysis shows a 75% reduction in running costs compared to regular fuel vehicles over the battery's life.

The ROI calculations look at several ways to make money:

- Direct charging fees
- Partnership revenues with fleet operators
- Advertising income
- Priority charging services

These systems show that when AI analytics help place charging stations in the right spots, they can earn about 7% ROI after covering all running costs. The benefits go beyond money - charging stations work better and customers are happier.

Grid Impact Assessment and Management

Smart control systems and careful planning help manage how EV charging stations affect the power grid. The grid needs sophisticated integration because a single EV charging station uses 6.6kW – equivalent to an entire house's power consumption.

Load balancing strategies

Smart grid technology helps distribute power loads efficiently across charging networks. Research shows we could power about 160 million vehicles using existing off-peak generating capacity. The system tracks energy use at each charging point and distributes available power. This ensures maximum output without overloading the infrastructure.

Advanced load management systems talk to individual chargers for smart power sharing. These systems can temporarily reduce power at certain stations to help others and prevent grid overload.

The charging load adjusts every second based on several factors:

- Charging urgency requirements
- Current energy pricing
- Customer priority levels
- Available power capacity

Peak demand optimization

Smart charging management has shown impressive results in reducing peak demand. Studies show that good demand-side management can cut energy costs by 20%. Adding EVs to these management systems reduces grid strain by 25% during busy periods.

Smart grid technology helps manage EV charging demand, especially during high-usage times. The system changes electricity prices based on current demand. This encourages users to charge their vehicles when fewer people are using power.

Grid stability maintenance

Grid stability needs constant monitoring of health and performance metrics. The system spots faults, demand changes, and unexpected events automatically. Electric Power Research Institute's research reveals a concerning fact - just two customers using 6.6 kW charging stations during peak times could overload about 40% of today's distribution transformers.

The system's advanced features let it adapt quickly to changing conditions. This helps maintain reliable operation. AI-driven charging algorithms calculate the best way to split energy between battery storage and grid power in real time. This method works well to prevent disruptions and minimize effects on grid operations.

Operational Efficiency Improvements

AI-powered predictive maintenance and smart resource management are the lifeblood of modern EV charging operations. Advanced AI algorithms help charging station operators to detect and resolve 80% of charger-related issues remotely.

Maintenance cost reduction

AI-powered predictive maintenance has changed how charging stations operate and maintain their infrastructure. The system looks at component wear patterns and spots potential failures before they happen. This proactive approach brings several benefits:

- Remote issue resolution capabilities
- Automated maintenance scheduling
- Reduced unexpected downtime
- Extended equipment lifespan
- Lower repair costs

The AI model triggers maintenance workflows and alerts technicians automatically when it predicts component failure.

This proactive strategy has reduced maintenance expenses by approximately 37% instead of waiting for equipment to fail.

Resource allocation optimization

Smart resource management focuses on creating better charging schedules based on multiple factors. The system looks at vehicle arrival times, departure schedules, and energy costs to find the best charging combinations. Particle swarm optimization algorithms make the system highly efficient, as it processes schedules for 500-vehicle lots in under 30 seconds.

Dynamic pricing models help spread charging demand throughout the day, despite their complexity. The system analyzes past usage patterns and customer behavior to make data-driven decisions. Charging station operators can maximize throughput and maintain service quality this way.

Energy efficiency gains

Advanced AI algorithms showed remarkable improvements in energy efficiency. The system achieved energy savings up to 49% during short 50km journeys by analyzing road topology and wind conditions. These savings remain unrealized if optimal routes aren't selected.

Renewable energy integration has definitely made a big difference. Studies reveal a 42% reduction in electricity demand at charging stations through renewable energy integration. This approach ended up reducing costs by 69% compared to non-renewable scenarios.

Time-of-use optimization is a vital factor in energy efficiency. The system calculates various charging schedule combinations and selects options that minimize costs while preventing grid overload. This approach reduces reliance on fossil-fuel power plants during peak hours and results in lower emissions and better grid stability.

Edge AI systems improve grid stability and optimize energy use through advanced demand forecasting and autonomous load adjustments. This integration supports vehicle-to-grid technology and provides ancillary services that make modern energy grid operations stronger.

Conclusion

Edge AI solutions are revolutionizing EV charging infrastructure with remarkable results. The numbers tell the story - a 22% boost in performance, 37% lower assistance costs, and 47% fewer call-out expenses. These results come from ground implementations that show what's possible.

Smart grid integration uses sophisticated AI algorithms to handle peak needs while keeping the grid stable. The system's speed is impressive - it processes charging schedules for 500-vehicle lots in just 30 seconds. On top of that, operators can spot and fix 80% of charger problems remotely, which saves a lot of money.

Energy efficiency gains are a big deal. Advanced routing algorithms help save up to 49% energy during short trips. The integration of renewable energy cuts the need for electricity at charging stations by 42%. These results show that Edge AI technology provides practical answers to the growing EV charging infrastructure needs, which will support the expected 50% EV market share by 2030.

WPS Women in Power Systems

WOMEN IN ENERGY: IT'S TIME TO SEIZE REAL POWER AND IMPACT!

The power systems industry has long been a male-dominated field, with women making up just 22% of the global workforce and holding only 12% of leadership positions, according to recent reports. Yet, approximately 50% of energy consumers are women — from charging phones to heating homes, energy powers our daily lives.

Today, we're seeing a commendable trend: women are increasingly stepping into leadership roles in the power systems sector. However, a critical issue remains. Too often, women in leadership hold titles that lack real executive power, limiting their ability to drive meaningful change.

How do we address this imbalance?
We've posed this question to engineers, CEOs, and team leaders from top companies in the industry, sparking vital conversations. The journey towards equal representation is ongoing, but we aim to be part of the solution. By fostering discussion, building a strong community of women professionals, and amplifying their voices, we can drive progress and ensure that women are not just present but leading with real impact.

Support and elevate the voices through Women in Power Systems.

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WOMEN IN POWER SYSTEMS
BE THE VOICE OF CHANGE

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