CHALLENGES AND OPPORTUNITIES AROUND POWER DEMANDS AND DATA CENTERS | AN ELECTRICAL SAFETY AND RELIABILITY ASSOCIATION (ESARA) REPORT

Editor's Note:

We welcome ESARA, the Electrical Safety and reliability Association, as a new Alliance Partner with APC Media. ESARA is also a sponsor of RED Talks, which we also feature in our Perspectives section. To access ESARA go to www.joinesara.org for free practitioner membership and to learn more about Corporate and Approved Provider sponsorship.

The electrical power industry is undergoing a historic transformation, with more change in the last five years than in any previous period. This transformation significantly impacts power demands, especially concerning the exponential growth of data centers, leading to both significant challenges and new opportunities for the industry.

CHALLENGES

Aging Infrastructure and Increased Demand: Power system assets, including transmission lines, substations, transformers, and motors, are aging and often operating beyond their designed lifespan. The average power transformer, for instance, is between 38 and 42 years old, designed for a 20-year life. At the same time, demand for power is not only increasing but concentrating, particularly due to the exponential growth of AI and data centers. This puts immense pressure on an already aging distribution system.

Massive Cooling Loads: Data centers require a significant secondary load for cooling, often representing a larger portion of the load than the computing itself. Failures in these cooling systems lead to data problems, not just HVAC issues, making their health critical.

"Dirty Power" and Inverter-Based Loads: The rise of renewables like wind and solar introduces more transients and harmonics into the grid, leading to "dirty power". This is exacerbated by inverter-based resources, which rely on power electronics and can cause transformers to go into premature failure if not properly sized.

Quality and Cost Pressures: While older electrical assets were often "overbuilt" for durability, competitive pricing pressures today mean that new transformers and devices are not built to last as long, creating a challenge for ensuring long-term quality.

Workforce Shortages and Knowledge Gaps: There is a dwindling supply of skilled trades to maintain aging assets, and older generations are retiring, leading to significant expertise and labor shortages. The required expertise today differs greatly from 30 to 50 years ago.

Photo: ESARA

Increased Risk with Reactive Maintenance: When maintenance is reactive—fixing problems only after they occur—the risk of incidents like arc flashes and electric shocks dramatically increases compared to planned, proactive maintenance.

System Complexity: The power system is becoming increasingly complex due to distributed energy resources (DERs) and inverter-based power generation, requiring more data and sophisticated information management. DER substations can cause existing transformers, cables, and system components to age twice as fast.

Supply Chain Issues: Before the COVID-19 pandemic, companies could wait for failures and receive replacement equipment within weeks; now, it can take years, forcing companies to maintain larger budgets for spare parts.

Local Opposition (NIMBYism): Utilities face challenges meeting increased demand, for instance, by running new transmission lines, due to local opposition. Not in my backyard!

OPPORTUNITIES

Shift to Proactive, Condition-Based Maintenance: There is a critical shift from reactive maintenance to a condition-based strategy rooted in real-time data. NFPA 70B's 2023 revision now mandates inspections, making them requirements rather than just recommendations.

Advanced Monitoring Technologies:

- **Continuous Monitoring:** The industry is moving towards continuous 24/7 monitoring of assets, which is becoming more cost-effective due to falling sensor prices. This allows for the detection of issues that develop between annual inspections.
- **IoT Sensors:** The deployment of sensors for the Internet of Things (IoT) provides vast amounts of data. IoT-installed sensors can gather data daily, which is particularly beneficial for remote data centers where travel is costly.
- **Multifunctional Sensors:** Modern sensors can detect multiple parameters simultaneously, such as temperature, humidity, ultrasound, and vibration.
- **Simple Indicators:** Technologies like color-changing clips and dots can indicate temperature problems or other issues without specialized training, providing ongoing feedback on asset health.
- **Predictive Technologies:** Infrared, ultrasound, and fluid or oil analysis have become far more critical for detecting early-stage faults before they become costly failures.

Photo: ESARA

AI and Machine Learning for Data Interpretation: The upcoming wave of "IoT 2.0" involves AI systems capable of interpreting vast amounts of data, eliminating the need for manual data management. AI can be trained through long-term trending and continuous system training to provide tangible and actionable information, leading to predictive failure analysis and alarm conditions.

Software Solutions and Data Consolidation: Companies are focusing on software solutions to manage distributed energy resource management systems (DERMS) and understand asset changes in dynamic power generation environments. Platforms that consolidate data from various measurement devices and sensors into a centralized system are emerging.

Focus on Humanized Safety: Companies like IRISS emphasize "humanizing safety," focusing on people to ensure individuals in the electrical space can return home safely at the end of the day. Proactive inspections and continuous monitoring contribute to this by preventing critical failures that could put lives at risk.

Bridging Knowledge Gaps: Simple technologies, like IoT sensors, can help bridge the void left by retiring subject matter experts, as they require less specialized expertise for interpretation.

Increased Redundancy: Manufacturers are increasingly accounting for redundancy in their power systems, with some facilities installing their own independent generating stations due to mistrust in grid reliability. Data centers often require their own power generation and energy storage.

By embracing these technological advancements and shifting towards proactive, data-driven strategies, the electrical power industry can better address the challenges posed by aging infrastructure and escalating power demands from critical applications like data centers.