Life Is On | Schneider Electric

Bringing critical power distribution out of the dark and into a safer, more reliable, and sustainable future

by Markus Hirschbold

Executive summary

Today, proven technologies exist that can fully digitize the electrical distribution infrastructure of significant and critical buildings and facilities. These are helping improve safety for people and assets, increase power reliability and business continuity, optimize operational and energy efficiency, achieve sustainability goals, and meet regulatory compliance.

Yet, most organizations are still not taking advantage of these latest advances in power distribution connectivity and intelligence, some of which may already be in place in their facilities. Without this crucial last step, facility teams are working blind, unaware of many hidden risks and opportunities.

Introduction

The pressures on organizations have never been greater. Businesses routinely face tough competition, while the boards of businesses and institutions expect improvements in efficiency – often with fewer resources – to help reduce costs and protect profits. At the core of keeping operations running smoothly is a steady flow of electrical energy, the most important input to critical operations.

This is why operations and maintenance teams for large and critical power facilities – such as hospitals, data centers, and continuous industrial processes – have five primary goals regarding their electrical infrastructure: electrical safety, power availability, sustainability, operational efficiency, and cybersecurity. Each of these goals continues to present serious challenges as well as great opportunities:

- **Risks to safety:** Electrical system issues are recognized as the cause of 22% of workplace fires,[1] while an estimated 25% of electrical failures are attributed to loose or faulty connections, according to a major insurance carrier.[2] This points to a need for more vigilance in finding sources of overheating. And while today's breakers reliably protect from overloads and short circuit conditions, hospital operating theatres are particularly sensitive to insulation faults, which can put lives at risk. Finally, if a facility-wide or localized outage occurs, power must be restored immediately to ensure occupants' safety and re-establish operations.
- **Risks to power availability:** Studies have shown that power quality disturbances cause 30 to 40% of business downtime and that 70% of those disturbances originate within the premise.[3] Any amount of power interruption can be devastating to an organization's operations. Given that the average outage in mission-critical facilities lasts 90 minutes,[4] these incidents represent a massive cost to businesses and institutions. Beyond lost productivity is the cost of replacing expensive equipment such as a failed transformer. Lawrence Berkeley National Laboratory

Figure 1

Facility teams for large and critical buildings need to maintain their electrical infrastructures' safety, reliability, efficiency, and compliance.

[1] Electrical Contractor Magazine, "Fire in the Workplace," 2004

[2] NETA World magazine, "Top Five Switchgear Failure Causes and how to avoid them," 2010

[3] A. E. Emanuel and J. McNeill, "Electric Power Quality," Annual Review of Energy and the Environment, vol. 22, pp. 263-304, December, 1997

[4] Emerson Network Power, "Understanding the Cost of Data Center Downtime," 2011

found that power interruptions cost the U.S. economy approximately $59 billion in 2015, increasing more than 68% since an earlier 2004 study. Commercial and industrial businesses account for more than 97% of these costs.[5] Many facilities also rely on backup power systems to support loads in case of a utility outage. This, of course, requires regular testing and maintenance to ensure backup power is available when needed. Preventing downtime requires 'seeing into the future,' or rather being able to identify when conditions on your power network are deviating outside of safe parameters or when protection settings have deviated from their original design.

- **Risks to sustainability and energy efficiency:** Beyond the costs of power-related interruptions, there are also the economic and environmental costs of inefficiency. The US Department of Energy estimates that "with the application of new and existing technologies, buildings can be made up to 80 percent more efficient or even become 'net zero' energy buildings with the incorporation of on-site renewable generation."[6] This presents a huge opportunity for organizations to reduce their energy consumption and carbon emissions, and in turn their operating costs. Also, emissions regulations are now common in most countries, while many corporations implement their own sustainability goals. In turn, this requires gaining visibility into every aspect of energy, from billing, to consumption, to on-site energy production.
- **Risks to operational efficiency:** Another big part of operational costs is facility teams' time and money to maintain power and buildings systems, often with limited staff. Maintenance represents 35% of a building's lifetime costs (IFMA, 2009),[7] so any improvements to team efficiency and equipment lifespan can represent significant bottom line savings. In fact, another Department of Energy study revealed that by implementing a program of condition-based predictive maintenance, a building can save up to 20% per year on maintenance and energy costs, while increasing the projected lifetime of the building by several years.[8] However, predictive maintenance requires a new level of analytic capabilities that can help predict equipment needs and enable collaboration with experts when needed.
- **Risks to cybersecurity:** With increased connectivity, use of IoT-enabled devices, and IT/OT convergence, it is critical that electrical systems are designed and updated to minimize cybersecurity risks. This includes the proper assessment of potential threats and vulnerabilities, as well as the specification of appropriate levels of security from the device to the system level. See white paper "Understanding cybersecurity for IoT-enabled electrical distribution systems."

This is a demanding set of challenges. What is even more concerning is that facility management teams in most large buildings and plants are still unaware of these risks and opportunities. The reason: a lack of visibility to enterprise-wide power and equipment conditions. Though the consequences of a power outage are severe, and the costs of energy and maintenance are high, most new and legacy facilities still use only a rudimentary level of technology to help prevent power system failures and minimize operational costs. When problems arise, the response is usually on a reactive rather than proactive basis.

[5] Lawrence Berkeley National Laboratory, "The National Cost of Power Interruptions to Electricity Customers – A Revised Update," January 2017

[6] Next10, 'Untapped Potential of Commercial Buildings: Energy Use and Emissions'

[7] Schneider Electric, "Predictive Maintenance Strategy for Building Operations: A Better Approach"

[8] Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency," Federal Energy Management Program, U.S. Department of Energy

Wastewater plant averts disaster

One of the largest wastewater treatment plants in the world was expanding its power management system. When the final metering devices were connected, the system immediately detected a serious problem.

The tiebreaker between the two incoming transmission lines was unexpectedly closed at one of the primary substations feeding the plant. Worse, a fuse was blown on one of the incomers, meaning dual incomer redundancy was lost. If there had been a grid outage on the remaining incomer, an entire plant section could have experienced a disastrous failure.

Fortunately, this risk was detected and corrected, highlighting the critical importance of 24/7 electrical system monitoring.

Intelligent power has arrived

Facility teams should be taking full advantage of the many applications and benefits that digitalization now enables. Without a fully connected and intelligent power management system, facility teams are 'working blind,' unaware of the many risks that may be threatening business continuity and efficiency. And risks progressively increase as new loads are added that could affect power quality, especially non-linear loads often used to improve energy efficiency such as LED lighting, VSDs, switching power supplies, etc.

Like advances in vehicle-based intelligence in the automotive industry, power distribution systems now include a complete network of smart, connected devices. These deliver timely, actionable information to facility teams through powerful software applications, either at the desktop, in the cloud, or on their mobile devices anywhere they are. The newest tools make it simpler than ever to understand power and energy conditions and manage complex power systems.

The steps to implementing such a solution can be extremely cost-effective, considering all the dimensions of ROI that can be achieved in a very short payback period. Many of the pieces may already be in place in most facilities, such as smart meters and breakers.

Once connected, facility teams will immediately benefit from:

1. early warning of risks
2. faster recovery from problems
3. identification of energy efficiency and sustainability improvement measures
4. revealing of time and cost-saving opportunities
5. streamlined maintenance
6. enhanced equipment performance and lifespan

This paper will show how a nominal investment in a digitalized electrical distribution infrastructure can help large and critical facilities meet core operational, sustainability, and regulatory goals more easily while gaining additional unexpected benefits.

Figure 2

Smart, connected devices are the first step in a completely digitized power distribution system.

The digitalization of power distribution

Digitalization is all around us. Consider the automotive industry. Cars today are some of the most digitalized machines in our lives, yet we all take for granted the incredible advances that have taken place in recent years.

Every aspect of the operation is monitored, displayed, and, in some cases, controlled automatically. These capabilities have vastly improved the safety, reliability, efficiency, and compliance of every kind of vehicle while improving ease-of-use and driving experience for owners. For example, vehicles routinely provide:

- Oil pressure, temperature, battery voltage, fuel level, coolant level, etc. sensors: make sure you are alerted in case of any malfunction before you get stranded on the side of the road
- Anti-lock braking system (ABS): prevent uncontrolled skidding
- Stability controls: prevent loss of traction (by sharing the same brake actuator and sensors with ABS)
- Automatic airbags: to protect driver and passengers in the event of a collision
- Emission sensing and control: to meet regulatory standards

More advanced capabilities might include:

- Tire pressure monitoring sensors: improve fuel economy and alerting the driver to a potential flat
- Backup cameras with proximity sensors: guide the driver into a parking spot
- Blind-spot monitoring: increase the safety of lane changes
- Lane departure warning: help avoid collisions due to driver error, distractions, and drowsiness
- Look-ahead radar: starts braking before a collision can occur

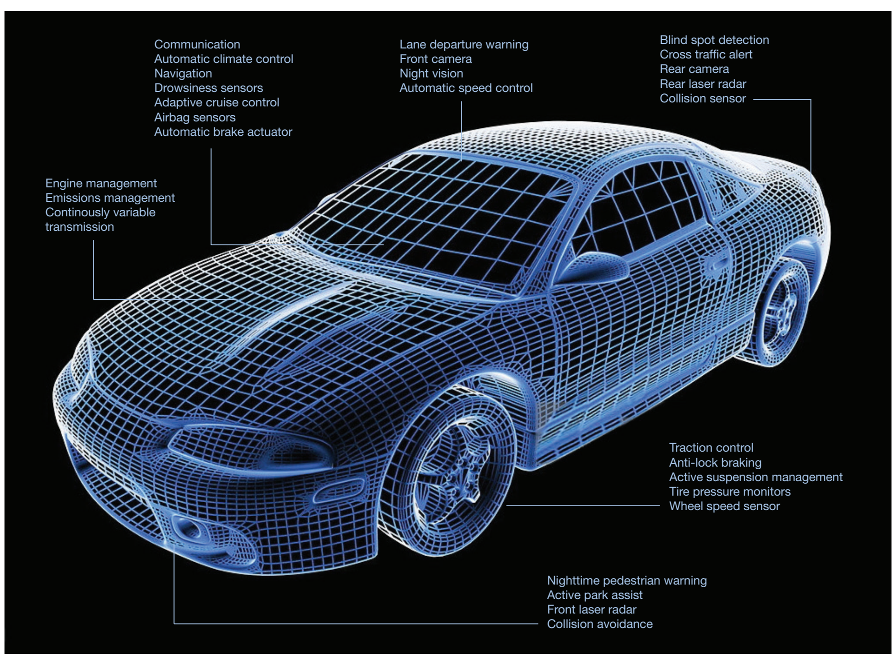


Figure 3

Advancements in automobile technology provide as standard equipment a vast array of sensors and intelligence in every vehicle.

University improves safety and reliability

For a large university, unpredicted power outages carry a high cost, both financially and potentially in lost lives at its medical center. After suffering a major transformer failure, the university built its own substation and installed a complete power management system.

The intelligent power quality meters and analytic software perform automated alarm monitoring, breaker status monitoring and control, and transformer temperature monitoring. The system helps schedule preventative maintenance, correct transient anomalies, and enables quick response to emergencies such as power outages and weather-related incidents.

Smarter power distribution

It is now unthinkable to deal with the extreme complexity found in cars without sophisticated digitalization. Imagine being an auto mechanic and having to troubleshoot a modern car without a diagnostic scanner.

The same is true for modern electrical distribution systems. Systems are larger and typically evolve to accommodate more loads, which are increasingly power-sensitive (e.g., automation systems). Many types of loads, such as variable speed drives, can also be the source of potential power quality (PQ) issues. Beyond energy-consuming loads, larger sites will often include on-site generation and storage, either for power backup, 'peak shaving' to avoid demand penalties or to consume self-generated renewable energy when it's most economical.

As the complexity and sophistication of our electrical distribution infrastructure increases, it becomes critical to have the appropriate digital sensors, advanced controls, and analytic capabilities to detect, diagnose, and correct issues before they cause mission-critical systems to fail. Touching every corner of a facility's electrical network, the latest 'edge control' software and mobile apps connect to smart devices to keep facility teams informed and reveal deep insights.

Like digitalized vehicles, digitalized power distribution optimizes safety for people and assets, while improving reliability and business continuity. It provides the data converted by analytic software to actionable information to help facility teams maximize energy efficiency and lifecycle efficiency. As an alternative to interval-based maintenance, digitalization enables condition-based maintenance, enabling equipment servicing to be performed at the right times to improve reliability and avoid unnecessary time and costs.

A digitalized power network also simplifies energy and emissions tracking and reporting for regulatory compliance, supporting participation in carbon markets, or publicly showcasing energy performance.

Finally, data from distributed devices can be automatically and continuously uploaded to cloud-based platforms, enabling 24-hour support from expert services. This can be especially valuable for facilities that do not have adequate in-house resources or expertise.

Simple steps to getting connected

Unlike today's vehicles, power distribution systems do not come 'stock' with complete digitalization. However, the technology is available, proven, and operating successfully in thousands of facilities worldwide.

Currently, the required devices, communication networking, and software applications need to be specified. It is expected that all of this will become a standard and ubiquitous part of every power distribution installation in the future.

The good news is that most newer power distribution systems may already have the connectivity available but may not have it implemented yet. Installed devices simply need to be networked together. Even legacy systems have simple retrofit possibilities to add the appropriate devices and sensors. These upgrades are highly cost-effective when considering the long list of benefits to the facility and the organization.

Let's look at the type of devices, communications, and architectures that make a digitalized power distribution system possible.

Smart, connected devices

The increasing connectivity of devices has enabled the digitalization of power distribution, aided by the global trend in the *Internet-of-Things* (IoT). More and more devices and sensors are becoming digitalized, with new kinds being introduced all the time. **Table 1** lists some common types.

Table 1

Typical types of smart, connected devices within a power distribution system.

Device / equipment	Data / control provided
Protection devices	
Circuit breakers	Trip units with embedded power and energy metering, breaker condition monitoring, diagnostics, alarms, data logs
Protective relays	Trip units with diagnostics, network status, alarms, data logs
Meters, monitors, sensors	
Energy meters	Basic single or multiphase energy consumption, data logs
Power quality monitors	Energy, power, demand, advanced power quality capture and analysis, equipment status, alarms, data and event logs
Environmental sensors	Temperature, humidity, gas, and pollution (e.g., to help avoid corrosion, reduced performance, etc.)
Arc-flash sensors and relays	Alarm on arcing condition
Vibration sensors	Vibration readings
Voltage, current sensors	Single measurements on each phase
Busbar temperature sensors	Temperature, alarm on exceeding threshold
Insulation Decomposition Detection	Detect overheating of insulated conductors too small for temperature sensors
Embedded equipment sensors, controllers	
UPSs, DC inverters, battery chargers	UPS status, battery levels, control functions
Gensets	Genset status, voltage, current, power, fuel level, temperature, control functions
Transformers	Temperature sensors, voltage, current
Automatic Transfer Switch	Switch status, control functions
Automation equipment	
Programmable Logic Controller	Data from connected devices, control functions
Remote Terminal Unit	Analog and digital input measurements

Devices can be integrated into a communications network in several ways. Wireless can be used for ease of installation, especially for simpler measurement or sensing requirements. Serial communications can make a good choice in some cases, especially as serial ports are common on many types of devices. Ethernet is the best choice where a large amount of data and fast data transfer are requirements, such as for more advanced power quality monitors and for communications hubs that aggregate data from many downstream devices.

Standards and communications data models, such as the IEC 61850 standard, are emerging for more effective universal and non-proprietary communications.

Most smart devices offer a choice of communication protocols for system compatibility. At the same time, some provide modular hardware designs that enable communication ports to be installed in the field for devices not already connected. Some more advanced devices also offer modular firmware architectures that allow functionality to be customized. This kind of flexibility allows devices to adapt to current and future needs.

IoT-enablement means smart devices can upload data directly to cloud-based data storage and applications, making for simpler data sharing and collaboration across one or more facility's operations and maintenance teams. Many devices also offer direct browser-based access to real-time and logged data using mobile devices.

An example of what an IoT-enabled electrical distribution architecture can look like is shown in **Figure 4**. This illustrates a simplified architecture for a hospital, highlighting devices at the medium-voltage, low-voltage, and final distribution levels.

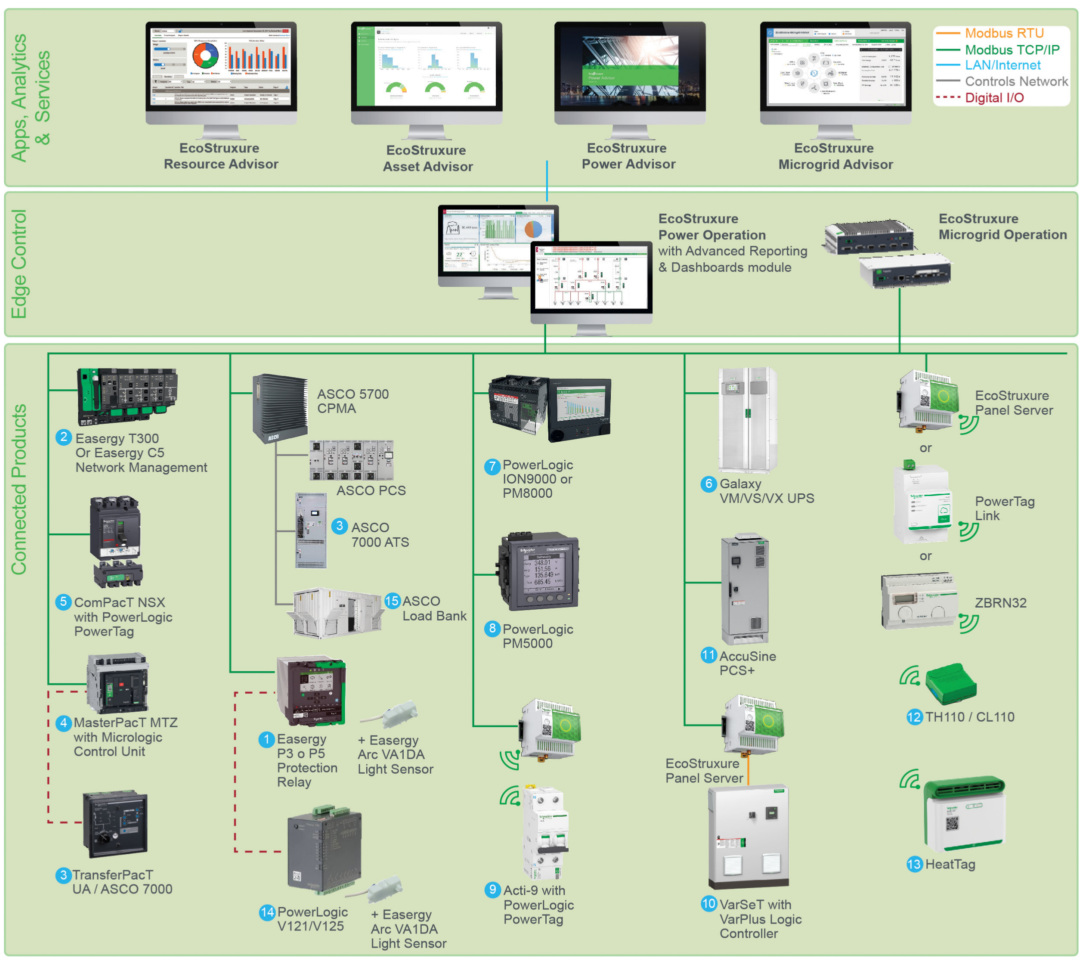


Figure 4

A typical digitalized power distribution monitoring network showing smart devices located at each level of the electrical system.

Powerful supervisory applications

In a digitalized power distribution system, a software application acts as the central collection point. All digital real-time and historical data is aggregated and made available to all stakeholders that oversee the electrical infrastructure.

The combination of software and device network is often referred to as an energy and power monitoring systems (EPMS). For large and mission-critical systems, supervisory control and data acquisition (SCADA) systems designed for power distribution are available. These have built-in redundancy that supports fail-safe operation, reliable control actions, and highest accuracy timing.

With central software, the benefits of digitalization come to fruition. Using connectivity to all the devices and equipment mentioned previously, the software can supervise electrical processes such as power transfers and network automation. This is commonly done with the help of ‘single-line’ diagrams that display power and energy conditions throughout the facility, as well as equipment status, see **Figure 5**.

Event data is captured and stored onboard each device with precise time-stamping, then automatically uploaded to the software. The software sends automatic email or SMS notifications for alarms and events to designated recipients. It will also provide extensive analytic capabilities to help diagnose and isolate sources of problems and reveal opportunities to improve power, energy, and equipment performance. The next sections describe how these tools simplify each process.

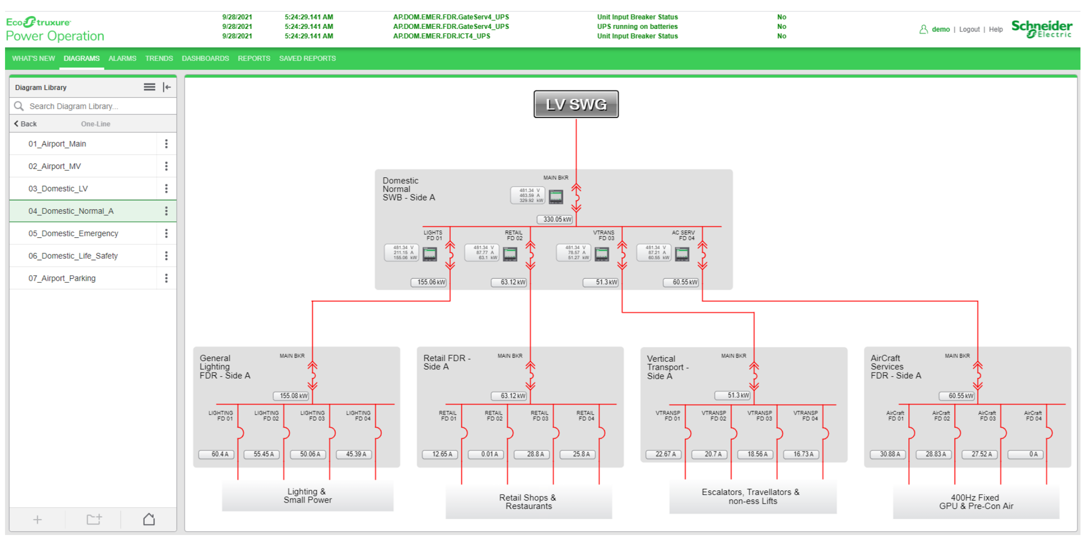


Figure 5

A typical ‘one-line’ diagram showing electrical conditions and equipment status throughout a power distribution system.

Power management made easy

Soap factory solves production stoppages

A soap making factory was experiencing mysterious production line stoppages about once a month. Each caused a four to eight-hour delay costing $20,000 (USD) per hour and $120,000 (USD) every month.

A networked power management system was installed. Smart power quality meters and analytic software determined the problem was power sags, swells, and transients coming from the utility grid.

The utility determined the problem was coming from a heavy equipment operator nearby that was generating disturbances back onto the grid. The utility installed new lines that isolated the plant from the problem, which resolved the downtime issue.

With a fully digitalized power system, facility teams can take advantage of a vast number of applications to help meet safety, reliability, sustainability, operational efficiency and cybersecurity goals. Desktop edge-control or cloud-based software and mobile apps enable access to devices distributed across the entire electrical infrastructure. At the same time, analytic tools make it simpler than ever to gain deep insights, enable decisions, reduce response time, and make operations and maintenance workflows more efficient.[9] Further, cloud-based advisor services, with experts helping perform analytic and advisory functions, can take the burden off the on-site facility team by assisting with preventive or predictive maintenance. See white paper "Do more with less: moving power and building management to the cloud."

However, it is essential to make sure the data received by analytic applications is accurate and reliable. Experience has shown that many systems are prone to wiring, configuration, and commissioning mistakes. It is vital to have an error-checking algorithm that detects all errors to be eliminated. Without this crucial step, incorrect decisions can result from unreliable data.

Optimizing safety

Preventing electrical fires. Up to now, electrical fire prevention has involved using infrared (IR) scanning. An IR camera is used to detect hot spots in bus bar junctions, transformer connections, or breaker contacts. This procedure is quite expensive and, therefore, is only performed at specific intervals, from twice a year to once every two years. The problem is that electrical fires are often caused by incorrectly performed maintenance procedures; therefore, the issue can be missed if the maintenance is done after the regular IR scanning has been performed.[10]

Fortunately, digitalization brings a more sophisticated and continuous approach to thermal monitoring. Wireless sensors installed in strategic locations detect abnormal temperature rises due to high impedance connections on bus bars or conductors, transformers, or breakers. Temperature data is wirelessly transmitted to the software or an asset monitoring service bureau. This allows for near real-time alarming in case of a thermal problem before it results in an electrical fire destroying equipment or injuring people. Thermal monitoring is effective at medium-voltage and low-voltage levels. Specifically, it also brings great value in busway applications to detect improperly tightened junctions. See white paper "Beyond IR Thermography: How continuous thermal monitoring improves performance and equipment protection."

Preventing electrical shock. Operating rooms and intensive care units in hospitals rely on isolated power to keep patients safe. Sensors in isolated power panels are connected to the power management network so that electricians can be remotely alerted to an insulation failure and, in turn, provide immediate assistance to surgical staff.

Recovering fast from outages. Responding effectively to an outage requires access to the right information when and where it is needed. An intelligent relay or circuit breaker trip unit delivers this information directly to mobile smart devices in a digitalized power network. Mobile devices can also be used to perform remote breaker control to restore power safely from a distance.

[9] Do more with less: Moving power and building management to the cloud

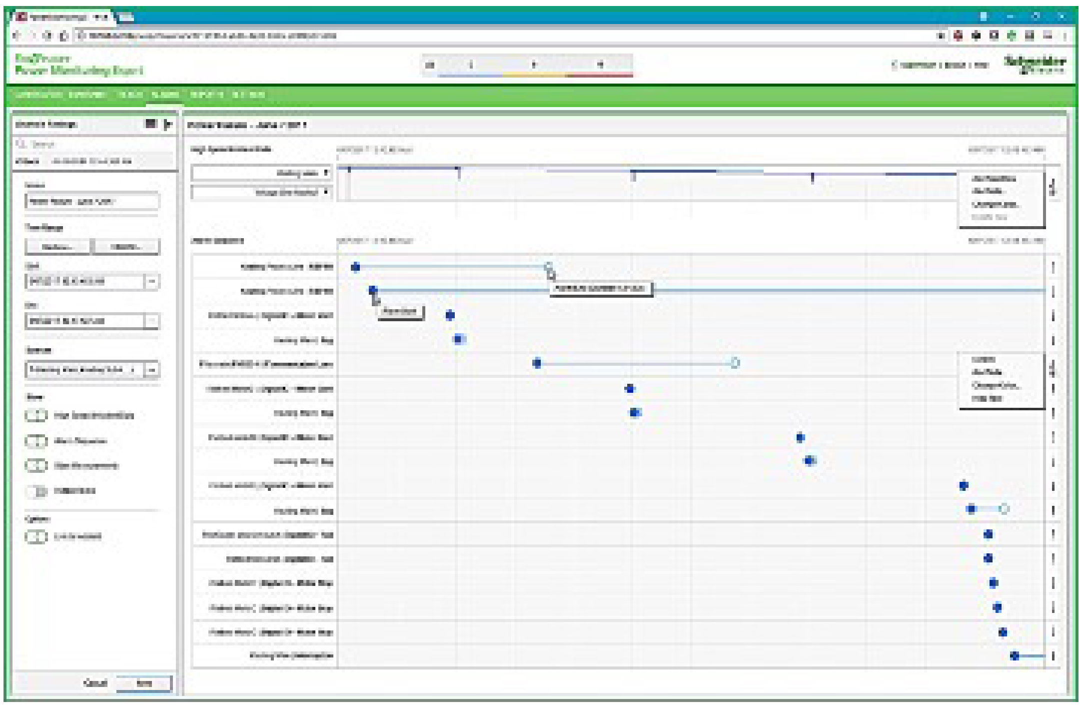
[10] Schneider Electric, "Beyond IT Thermography: How continuous thermal monitoring improves performance and equipment protection"

At a workstation, sophisticated software tools allow for advanced power forensics, speeding up the diagnosis of power incidents. Due to the high-accuracy time-stamping of events that occur onboard smart devices – e.g., distributed meters, relays, data loggers, etc. – a visual timeline can automatically create related events, waveforms, and trends, see **Figure 6**. Custom filters can be used to show only what is most relevant.

Additionally, a patented diagnostic capability from Schneider Electric named *Disturbance Direction Detection* makes it easier than ever before to determine where disturbances are coming from. Power meters automatically analyze every captured waveform, indicating the direction that a disturbance was traveling. With many meters connected to central power management software, it is possible to see how a disturbance flowed through the electrical distribution system, revealing if it was coming into a facility from the grid or originating from inside the building. This capability saves a tremendous amount of time in diagnosing problems.

Figure 6

Advanced event analysis shows related incidents on a visual timeline, revealing how an event cascades through the system and enabling the facility team to isolate the problem's source quickly.



Precise time synchronization, cross-system correlation, and Disturbance Direction Detection all help to reconstruct event sequences before, during, and after an incident. This helps operations personnel understand how incidents cascaded through the system, quickly find the root cause of the event, and enable steps to be taken to restore power quickly. Analytical results can be annotated and saved for later consideration.

Airport maximizes use of infrastructure

A large international airport digitized their electrical distribution system with automatic data collection from key points throughout. The goal was to improve the overall reliability and efficiency.

The system identified peak loading on all distribution equipment, as well as helping determine when non-critical loads could be shed, helping avoid overloading that could cause outages and equipment damage.

Trending capabilities also helped maximize equipment utilization by identifying areas of excess capacity.

Improving reliability

Avoiding downtime. By staying connected 24/7 to every point in the electrical distribution network, the real-time state and conditions of the network can be monitored for any deviations from normal operating conditions. If this occurs, the right people can be notified automatically, who will have detailed alarm data to determine the problem and respond before an outage can occur. Chronic power system events can be analyzed using the root cause analysis tools mentioned above to help in preventing future occurrences.

By constantly monitoring load trends through a facility, active load management can be used to prevent overloads and, in turn, business disruptions. This information can also be used to uncover unused capacity and for capacity planning for new facility expansions, avoiding overbuilding, and minimizing CapEx.

Large and critical facilities have a hierarchy of protective devices, typically with *molded case circuit breakers* at the medium voltage level and *compact circuit breakers* at the final distribution level. To properly isolate faults, a circuit breaker must trip upstream of a fault, also referred to as breaker *selectivity* or *co-ordination*. During facility commissioning, a co-ordination specialist ensures that all breakers are configured such that a downstream breaker always operates before an upstream breaker. This minimizes the impact of a fault on the overall electrical system.

In recently commissioned facilities, breaker co-ordination is typically intact and configured as designed. However, over the life of a facility electricians and operators tend to 'tinker' with breaker settings in response to nuisance trips or expansion of loads. This compromises selectivity and can result in trips for a much larger part of the network than intended. Thanks to digitalization and connectivity to edge-control software or cloud-based analytics, it is now possible to dynamically and continuously analyze breaker co-ordination, generating an alarm in case of any co-ordination violations. A 'digital twin' captures and stores the original co-ordination settings of each breaker, detecting any deviation that will result in undesired consequences. This added level of intelligence can help maximize breaker performance and reliability of the overall electrical system over the longer term.

Increasing asset reliability and lifespan. A recent trend in facilities has been replacing linear electrical loads with non-linear loads such as LED lighting, variable speed drives, and switching power supplies. This is typically done to conserve energy. However, non-linear loads introduce harmonics that can affect sensitive electrical equipment. As a facility starts to transition to these alternatives, they may not, at first, appear to be causing any problems. But, as the number of non-linear devices increases, the level of harmonics can get to a point where sensitive equipment is being affected.

This situation is typical of most power quality problems. Many facility managers may be heard saying, "We have never had problems with harmonics or power quality. It is not something we are concerned about." Then, one day, their mission-critical machine starts to fail.

Hospital reveals source of dialysis machine failures

A large hospital was experiencing failures of their blood dialysis machines due to an unknown source.

A power management system was installed and used to analyzing system-wide power quality. It was determined that the dialysis machines were sensitive to increased harmonics in the electrical system, coincident with the recent installation of variable frequency drives.

Appropriate harmonic filtering was installed, which solved the problem.

All the relevant information needed to identify power quality issues will help manage their impact and keep them from disrupting business operations or damaging critical loads and equipment. Sensitive equipment must be protected from harmonics, voltage sags, swells, flicker, transient voltages, or brief interruptions. A fully digitalized power distribution system helps prevent these by providing early detection of conditions before they exceed levels that harm equipment.

Another threat to reliability is high temperatures and humidity. These can prematurely age the components in power distribution switchgear, especially when operating in extreme or outdoor environments, and when pollutants are present such as salt. Compact, affordable sensors are now available that measure both temperature and relative humidity.[11] Sensors are battery-operated and transmit data wirelessly to the analytic software for analysis. If environmental conditions exceed defined thresholds and durations, maintenance teams can perform required maintenance to help avoid corrosion, equipment failure, and downtime.

Depending on available in-house skills, temperature, humidity, and power quality issues can be analyzed and evaluated on-site by the local facility team. Alternatively, this can be outsourced to a cloud-based advisory service.

Boosting efficiency

Managing energy consumption and costs. Since energy represents a significant line item for any facility, especially energy-intensive ones like data centers, finding ways to reduce energy spending can significantly impact the corporate bottom line. The first step to achieve a massive payback is to use accurate 'shadow metering' and energy analytics to verify that a facility's utility bill is accurate, both from a metering and bill calculation perspective.

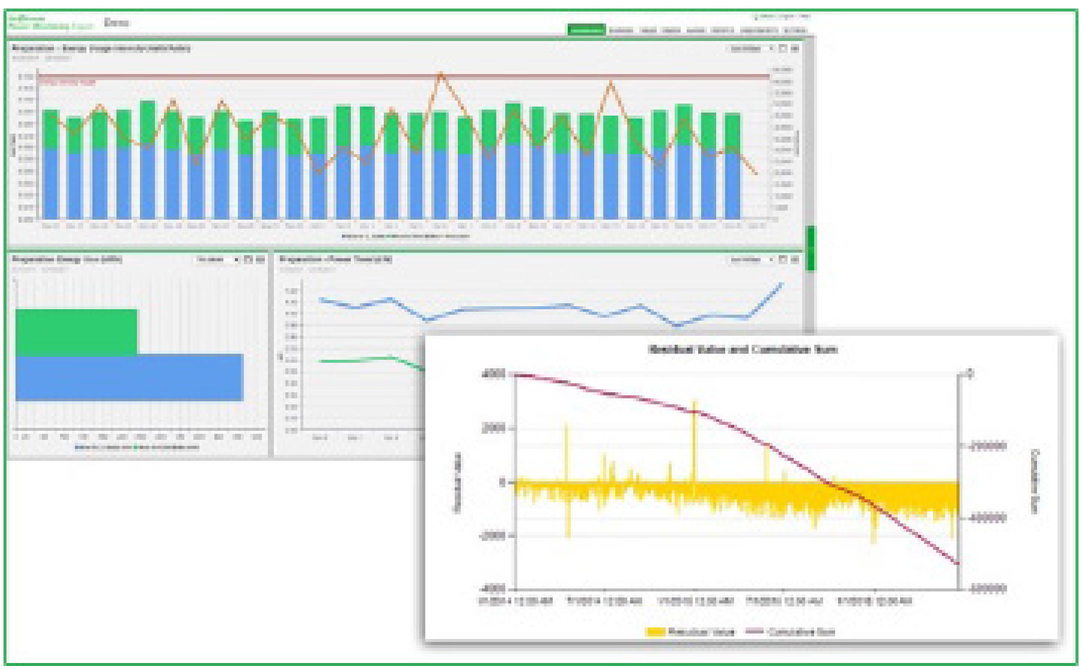


Figure 7

Energy analysis tools allow the import of contextual data (e.g., weather) to track energy performance, conduct energy analysis, and calculate important KPIs. Analytics reveal the difference between modeled (pre-retrofit) and actual (post-retrofit) data, helping weigh the results of energy conservation measures against target.

[11] Schneider Electric, "How To Control The Impact Of Severe Environments Surrounding Medium Voltage Switch-gear"

The next step is to encourage energy-efficient behavior and support cost accounting by accurately allocating direct and indirect energy costs to departments or processes. The software can also benchmark and compare energy usage across buildings, plants, or process lines to uncover inefficiency and waste. The energy performance of a facility or building can be analyzed against a modeled baseline that considers relevant energy drivers, such as weather, production levels, etc., see **Figure 7**.

Then, drilling down to see how much energy is consumed by the various load types and/or areas in a facility will help to determine where to focus energy conservation initiatives. Before and after analysis will help verify the energy savings from an energy retrofit or energy savings program. Some of these initiatives might include eliminating power factor penalties (e.g., by installing appropriate PF management equipment) and, as noted previously, avoiding demand penalties using peak shaving or active load management.

Managing multiple energy sources. A digitalized power distribution system helps leverage on-site energy production and consumption to boost cost savings and uptime. These energy sources might include solar, combined heat and power systems, or gas or diesel-fueled backup generators. It could also have an energy storage system. Such integrated systems are typically referred to as *microgrids*. They can be operated in parallel with the main utility grid or can sometimes be operated in an off-grid *islanded* mode in the case of a grid blackout.

Children's hospital uncovers energy saving opportunities

With an intelligent power and energy management system in place, a hospital was able to allocate energy costs to different sections, with alarms set for excessive consumption.

The system analyzes consumption patterns for individual equipment. This supports load-shedding operations to avoid peak demand penalties and load management to reduce base energy costs. This has also identified areas to improve energy efficiency.

Digitalization also enables access to value-added services on the 'smart grid,' helping a facility team optimize when to consume, store, or sell energy back to the grid. Advanced on-site or cloud-based microgrid control systems can provide predictive source management with inputs such as weather, energy cost, and other parameters to drive energy source control decisions. Many solutions are modular in design, offering scalability to manage smaller commercial microgrids up to large-scale, islanding-capable systems.

Optimizing maintenance. A digitalized electrical network gives a voice to critical energy assets. It enables equipment to provide the relevant condition-based information to maintenance teams to identify when they require servicing. This is a more proactive approach, in contrast to servicing only at regular intervals, saving time and money while also catching risk conditions that might otherwise be missed.

An example of condition-based monitoring is breaker-aging analysis. This innovative new capability provides some of the most advanced circuit breakers and power management software. Breakers report on the condition of their contacts, as well as many other operational parameters, while other sensor inputs report on environmental conditions that can affect breaker health, such as temperature, humidity, and corrosive gases. In combination, a more accurate picture of the aging of a breaker can be determined to help drive the appropriate maintenance protocol. This can help enhance the performance, reliability, and lifespan of each breaker.

Outsourcing facility management functions. Today, many facilities struggle with the 'brain drain' dilemma when experienced electrical engineers and electricians retire, and it is difficult to find new young talent. It is becoming more and more common for facilities to outsource some or all their facility management tasks.

Shoe factory achieves LEED certification

A large shoe factory sought to achieve LEED certification using several steps, including installing a system to monitor and modify the factory's energy use.

Using distributed metering, web dashboards, and reporting tools, the factory reduced energy usage by 18%, which helped achieve LEED certification. The system also allocates costs to 11 different factory sections to help measure and balance energy use.

Return on investment has been $US 5k per month in energy savings, with a payback period of 20 months.

Digitalization is a wonderful enabler for this since it enables 3rd party facility management companies to offer competitive analytic and advisory services, including monitoring multiple facilities from a central operations center. Many of the newest cloud-based power and energy management solutions allow for data sharing with outsourced expert services. These services facilitate condition-based maintenance, ensuring maintenance is focused where needed, the right maintenance is performed at the right time, and optimized maintenance spending.

Simplifying compliance

Committing to sustainability. Energy analytic platforms enable facility teams to benchmark energy consumption concerning national or international energy efficiency certifications bodies and to share energy reduction success with the public.

Systems will help track and report on carbon emissions for public disclosure and transparency to boost green image, meet regulatory compliance, or participate in carbon markets. Many applications also provide simple ways to showcase energy performance to stakeholders via public dashboard displays, encouraging energy awareness and energy-efficient behaviors.

Testing backup systems. Organizations like hospitals must regularly test and report on their backup power systems (generators, UPS, etc.). This process can be demanding; however, the newest power management systems can help simplify this process by automatically generating compliance, test, and maintenance reports to save time and reduce human error.

Ensuring supplier power quality. It is critical to validate that power quality inside the facility meets the required standards for the reliability of sensitive equipment. This includes ensuring that a facility's power provider is meeting contract obligations regarding power quality. Power management systems provide a range of capabilities to help simplify this.

Advanced power quality meters provide on-board PQ compliance monitoring and analysis, while analytic software aggregates PQ compliance data from across the facility. Combined reports can be generated that help facility teams track PQ trends and identify the source of risks, including problems coming from outside the facility on the utility grid. These reports can be used as evidence when bringing issues to the power provider.

Gaining cybersecurity peace of mind. Attacks on critical infrastructure, in general, have been on the rise, with a recent survey conducted by McAfee revealing that in "one year's time one in four have been the victims of cyber extortion or threatened cyber extortion; denial of service attacks had increased from 50% to 80% of respondents; and approximately two-thirds have found malware designed to sabotage their systems."[12]

Like the corporate IT network, digitalized power distribution systems are critical and vulnerable infrastructures that need protection. Any choice of digitalized solution should adhere to cybersecurity best practices, such as IEC 62443. These should include security training to developers, adhering to security regulations, conducting threat modeling and architectural reviews, ensuring secure code practices, and executing extensive security testing. For more information on mitigating cyberattack risks, see the white paper "Securing Power Monitoring and Control Systems."

[12] James Christopher Foreman, Dheeraj Gurugubelli, "Cyber Attack Surface Analysis of Advanced Metering Infrastructure," July 2016

Fast payback

The extensive (yet, not exhaustive) list of applications and benefits presented above makes a good case for digitizing facility electrical distribution networks. Such an investment is highly cost-effective, representing tangible ROI. A single solution offers a complete network of smart devices and multiple analytic desktops and mobile applications. The optimal architecture can achieve many different functions with the right mix of meters, monitors, sensors, transducers, and software.

Once in place, the facility can monitor, alarm, and report tools that enable enhanced safety and reliability, real energy and operational savings, optimized use of the power infrastructure, and simpler workflows. As such, a digitalized power system will optimize both CapEx and OpEx. Though digitalization increases installation costs by 10 to 20%, it results in significantly lower operating costs over the long term.

The increase in CapEx is typically paid for in less than 2 years.

Advances in technology have enabled a nominal incremental investment in digitalization of the electrical distribution infrastructure to reap a very large and fast return on investment.

Also, a powerful single solution with multiple capabilities can pave the way to the future, allowing new challenges to be addressed, sometimes with unexpected additional benefits. For example, consider how vehicle wheel speed sensors first designed for ABS functionality also spawned traction control capabilities. But those same sensors can also be used to track humidity cycles which can help avoid dust build-up that can cause arcing, fires, and failures. Similarly, having temperature sensors on conductors and connections can help prevent overheating, fire, and equipment failures.

Conclusion

The benefits of digitalization of the electrical distribution infrastructure in critical buildings and facilities are almost limitless. The categories of benefits are analogous to the advances in the automotive industry, bringing improved safety, reliability, and efficiency, and simplification in areas such as regulatory compliance.

However, due to the aging infrastructures of facilities such as hospitals, airports, wastewater treatment plants, etc., electrical distribution has not kept up with the latest digitalization technology trends. As such, most facility teams are still working 'in the dark' by not leveraging available, proven IoT-enabled power management technology to its fullest to achieve optimal performance. Digitalization brings insight into costs and risks that are otherwise unmanageable or unforeseen.

Fully digitalized electrical distribution systems are becoming the standard with pre-installed transducers and sensors. Digitalization occurs in three layers, from connected products to on-site supervisory applications, to cloud-based analytics and advisory services that support facilities without the required skills and resources. It is essential to have digitalization in mind when designing, building, or upgrading facilities. It is more cost-effective to have electrical distribution equipment already digitalized from the factory; however, digitizing existing installations will result in huge benefits and savings. See white paper "Power Digitalization: Understand and Achieve Active Energy Management in Buildings."

The payback from digitalization retrofits, or the added cost of a digitalized infrastructure for new construction, can occur in several ways. For example, in a critical facility like a data center or hospital, avoiding a significant power outage can deliver instantaneous payback. In the case of energy-related costs savings (e.g., optimized energy bill, energy usage reduction) or maintenance cost savings (e.g., predictive practices, extended equipment life), payback is usually within two years. The benefits outweigh the costs to avoid dust build-up that can cause arcing, fires, and failures. Similarly, having temperature sensors on conductors and connections can help prevent overheating, fire, and equipment failures.

Resources

- Customer Success Stories Web Page
- Power Digitalization: Understand and Achieve Active Energy Management in Buildings
- Designing Electrical Systems for Future-proof, Energy-efficient Green Buildings
- Beyond IR Thermography: How continuous thermal monitoring improves performance and equipment protection
- Do more with less: Moving power and building management to the cloud
- Understanding cybersecurity for IoT-enabled electrical distribution systems

About the author

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Markus is responsible for offer creation of EcoStruxure Power, the IoT-connected solutions of Schneider Electric, designed to improve every aspect of power distribution systems. He has held various key positions in R&D, Services, Power Quality, Project Management, and Offer Marketing in over two decades of tenure at Schneider Electric.

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