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Intelligent power starts with accurate, actionable data

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IoT connectivity for circuit protection lays foundation for system-level intelligence

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Powering Business Worldwide

Connectivity at the foundation of the electrical system

In 2017, businesses spent an estimated $964 billion on connected hardware. By 2020, analysts indicate that an estimated 31 billion "things" will be connected to the internet. As the world becomes more digital, electrical infrastructure is rapidly evolving and offering new ways to support more integrated, customizable, intelligent, and efficient buildings and processes.

The data provided by these billions of connected devices can be used in commercial and industrial settings to provide new found system visibility and predictive diagnostics that can create fail-safe systems, enabling functionality that was not previously available.

Ultimately, these outcomes can yield significant improvements in productivity in terms of throughput, dramatic increases in uptime, reduction in electricity consumption, and measurable quality improvements.

Intelligent power leverages this digital revolution and drives innovation through a combination of smart assets, connectivity, data science, and business models that are creating new interactions. At the heart of intelligent power are "things" that produce, collect, and process data. This data can help generate insights to make better decisions as more technologies have built-in connectivity for the Internet of Things (IoT).

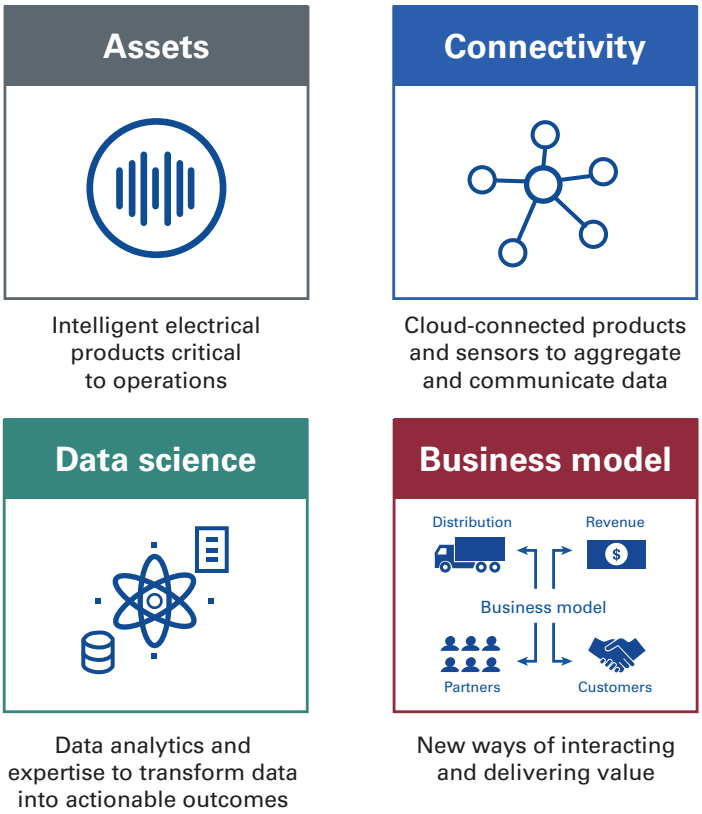


Figure 1. Intelligent power driving digital innovation.

By applying real-time monitoring and communications at the heart of an electrical system, end users can collect data, learn more about their system, and generate actionable insights. Those users can then leverage that knowledge to optimize power usage, improve system continuity and uptime, and lower operational costs. This type of digital connectivity can exist on the manufacturing floor, within commercial buildings, across healthcare facilities, in the home, or on the electrical grid.

When it comes to the electrical system, there are powerful advantages to connectivity and intelligence for foundational electrical components including circuit breakers. Circuit breakers are used in nearly every electrical system and perform a fundamental function; interrupting current flow in the case of an overload or short circuit. With the latest innovations, they are now also on the frontier of intelligent power management.

Figure 2. Intelligent and connected technologies are driving higher-level system visibility and predictive diagnostics.

Traditionally, circuit breakers were electromechanical devices designed to protect conductors (insulated wires) by opening automatically before excessive temperatures caused damage. Decades of circuit breaker design, testing, and application knowledge are being applied to develop algorithms that provide new embedded intelligence in Eaton's Power Defense™ circuit breakers with Power Xpert Release (PXR) trip units. These circuit breakers revolutionize circuit protection and provide innovative new features more akin to a smartphone, while also supporting traditional safety functionality. In a building or on the factory floor, Power Defense circuit breakers support more detailed levels of system visibility and enable predictive diagnostics, which translate into powerful system advantages including:

- Making higher levels of uptime possible through better connectivity and remote optimization of system parameters.
- Driving condition-based maintenance that's more cost-effective and efficient than traditional approaches.
- Supporting enhanced safety — through ARMS and visual indication of Zone Selective Interlocking (ZSI).
- Creating smart and connected equipment or extending and enhancing the capabilities of legacy equipment.

For example, in a connected factory, intelligent power management technologies like Power Defense circuit breakers can provide the real-time visibility needed to proactively mitigate unplanned downtime and manufacturing inefficiencies. This can have a major impact on the competiveness of businesses, as studies show that the annual cost of unplanned downtime for manufacturers is in the range of $50 billion. Digitizing factories to create a unified network of intelligent and connected devices can drive actionable outcomes in terms of preventative maintenance, training, production planning, quality, energy savings, and more.

Collecting and processing data

New intelligent circuit breakers contain more internal sensors to provide continuous monitoring and an accurate picture of circuit breaker and system status. Today, circuit breakers can monitor the ambient and operating conditions including length of service, temperature, current, number and severity of interruptions, event history, and voltage.

Additionally, new and powerful breaker health algorithms provide all the diagnostic indicators needed to monitor the status or health of the individual device. Through this innovative technology, facility and system operators are able to track the health of fundamental electrical system components in real-time and over time.

Analysis can be performed through the algorithm in the trip unit to get a sense of the device and system health. This data can then be communicated through Eaton's intelligent PXR trip unit to the building management system, facility control system, or the cloud. The real-time data can be further leveraged to support an electrical system that is more integrated and automated with the overall facility or process.

Furthermore, these intelligent circuit breakers will provide a new level of insight on the devices that are connected to the power distribution system including critical information that can be used for predictive maintenance of critical systems. Leveraging this actionable data, facilities can intervene proactively to perform critical maintenance before there is a failure, improving their productivity and cutting their operational cost.

Industry standard protocols establish connectivity

A key aspect of intelligent power is connectivity — it is transforming the way systems interact with one another. Connected devices need to easily connect to each other and the outside world to transmit the data, which is central to the benefit described here. The challenge is twofold: connecting devices to generate streams of data and turning this newfound information from multiple devices into actionable data for the overall electrical system.

Eaton's approach to connectivity and furthering intelligent power emphasizes industry-standard protocols (as opposed to proprietary ones) to aggregate and disseminate data, so that data can be easily incorporated into existing building management and distributed control systems (DCS). Nearly every electrical system incorporates devices from multiple manufacturers, and components that are part of a more connected system need to support the protocols that end-users are already applying in their facilities and processes. Components, like Power Defense circuit breakers, that use standard protocols can help meet this important consideration.

Further, a communications platform that is open, scalable, and secure can transform the way systems, devices, people, and processes interact while reducing project start-up time and associated costs. This approach supports connectivity in an environment that includes devices from multiple manufacturers and reduces the costs of getting components online.

Eaton's PXR trip unit technology with embedded intelligence is the first to enable this kind of connectivity for a fundamental power system component. Beyond providing essential safety functionality, Power Defense circuit breakers empower a building owner to perform sub-metering and load aggregation with a single device that supports easier connectivity, more functionality, and agnostic communications.

Today, Power Defense circuit breakers with PXR trip units incorporate metering and advanced algorithms to communicate the power system and circuit breaker status to the building management system, network, or the cloud. The ability to tap into any of these interfaces is important and enables connectivity to the existing infrastructure or establishing a dashboard if needed. From there, a dashboard, operator interface, building management system, or cloud-based system can transform the data generated by electrical components into business system level intelligence.

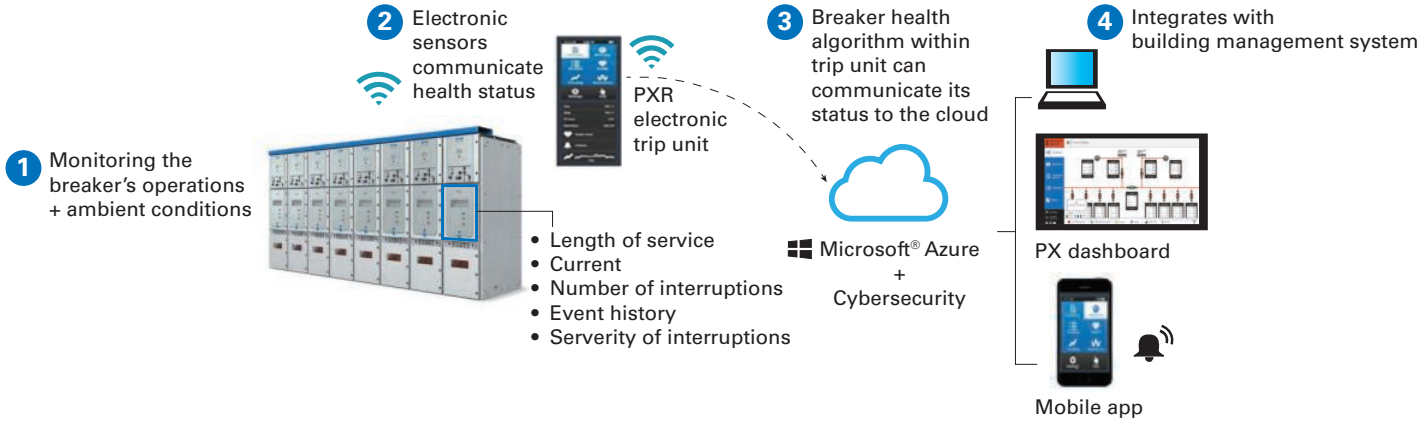


Figure 3. Embedded intelligence in circuit breakers provides an accurate picture of system status.

Turning data into intelligence

With cloud computing and digital factories, every piece of equipment that generates data has the potential to be securely linked to a vast set of web information. Well-defined goals and program objectives enable personnel to focus on specific aspects of collected data and analytics to maximize ROI and drive improvements that advance preventative maintenance, save energy, boost productivity, reduce or avoid downtime, and dramatically reduce manufacturing costs. Over time, collected data from devices can provide trend information to improve new and existing electrical system architecture and drive new levels of reliability and reduce maintenance.

From a remote management standpoint, cloud connectivity of facility data can enable powerful insights that improve business results. For example, management teams can be notified immediately of alarm notification remotely through cloud connectivity, reducing downtime, equipment damage, and related costs. Even small fluctuations in equipment performance can be used to predict failure and enable personnel to avoid downtime and equipment damage. More broadly, remote and decentralized access to real-time monitoring of equipment and building systems can:

- Keep personnel informed with critical data through a secure dashboard.
- Provide notifications and enable personnel to address issues remotely.
- Help spot energy usage anomalies, identify and enable personnel to adjust equipment.
- Enable a shift from reactive to preventative maintenance.
- Enhance safety by avoiding unnecessary, calendar based maintenance of all breakers that could expose electricians to shock hazards.
- Provide the detailed forensic data to determine the root cause of power problems.
- Deliver long-term power and energy usage information needed to make smart capital investment decisions.

Further, the ability to monitor systems remotely can support compliance with industrial and government regulators — particularly in critical facilities. With electronic logs of energy usage and system data, creating reports becomes as easy as pressing a button.

Driving actionable outcomes, what do we hope to learn?

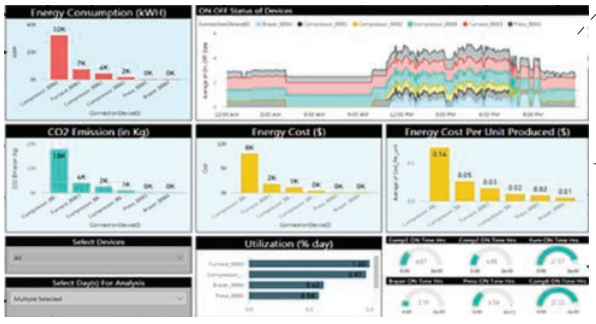
- Data to target throughput increase
- Diagnostics insights to reduce equipment stoppage and increase uptime
- Performance data across multiple machines
- Information to reduce energy consumption and costs
- Predictive insights to determine when a process change is needed

Cybersecurity by design

While connected and intelligent power systems offer tremendous benefits to companies, there are security concerns that must be addressed where any such system is connected to a network. Discussions of connectivity and building system intelligence must look at cybersecurity and address those risks through science-based assessments and evaluation.

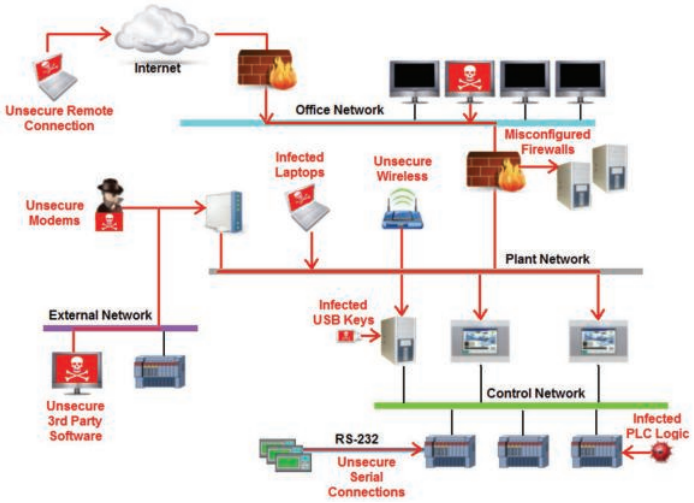
Recent security breaches have demonstrated that cybersecurity continues to evolve and vulnerabilities in both software and hardware continue to be identified. Consequently, it is imperative that cybersecurity features are designed into the system components and must be addressed in the overall system design. It is critical that organizations practice comprehensive cybersecurity practices including certification and testing.

Eaton provides connectivity options to meet customers' varied needs. Products can be connected to highly-secure, cloud-based big-data analytics engines for the highest levels of information and analytical performance. Alternatively, localized fog computing environments offer physical layer security while still providing a level of analytical benefits and reporting beyond what's available from disconnected equipment.



- Vibration
- Average asset utilization
- Day of the week
- Production output
- Off/on status of devices
- Voltage regulation
- Power watt peak day
- Setup specs
- Part number
- Humidity
- Supplier
- Conformance data
- Air pressure
- Material thickness
- Stroke speed
- Machine type
- Cure time
- Water flow
- Temperature
- Material waviness
- Real-time voltage anomalies
- Weekend energy consumption
- Plant power consumption pattern
- Energy consumption
- Operating time
- Peak demand cost
- Machine repair
- CO_2 emission
- Daily peak power
- Total energy cost

Figure 4. Through technologies like Eaton's Power Defense circuit breakers equipped with PXR trip units, factories or buildings are able to gather a range of data.



It is important to note that cybersecurity, even when designed into technology, is dependent on how technology is applied. For example, if a consumer buys a smartphone, it is the consumer who is responsible for applying manufacturer-provided updates; if those updates are not applied, the device may be more vulnerable to an attack versus an updated device. Similarly, how a customer applies technology and the updates and upgrades decided upon for their system and environment, will impact cybersecurity in the application.

However, a "defense-in-depth" approach that was considered effective yesterday may not be effective tomorrow because the ways and means of cyberattacks change. Administrators of building management and control systems need to be alert to changes in cybersecurity and work to prevent potential vulnerabilities. Manufacturers like Eaton post security notifications and firmware updates to address evolving cybersecurity concerns. Cloud-based solutions can provide automatic updates that are easy to manage.

At Eaton, it is our goal to ensure our products are compliant with cybersecurity standards and are secure when deployed in our customers environment by addressing cybersecurity from the beginning of product development life-cycle. Eaton's approach to product security advances safety and protects the availability, integrity, and confidentiality of electrical systems. Eaton's secure development approach also helps manage cybersecurity risks in products through the entire product life cycle — from threat modeling, requirements analysis implementation, and verification to ongoing maintenance.

A connected world requires trusted environments as more and smarter technology is introduced. Eaton established a cybersecurity collaboration with UL® that expands the company's commitment to advancing connected new technologies, while building trust and ensuring the highest level of defense against emerging cybersecurity threats. In addition, Eaton's cybersecurity research and testing facility in Pittsburgh is the first lab approved to participate in UL's Data Acceptance Program for cybersecurity.

The program aligns Eaton's testing methodologies and data generation with the UL Cybersecurity Assurance Programs for UL Standards 2900-1 and UL 2900-2-2. Through the UL Cybersecurity Assurance Program, Eaton, UL and other industry organizations are working together to establish foundational requirements for testing network-connectable industrial control systems to enable protection against vulnerabilities and security risk controls.

Beyond the UL standard, which is designed to address device-level security, there are also system-level approaches to security that have been established by the International Society of Automation (ISA) and International Electrotechnical Commission (IEC) ISA/IEC-62443 (ISA-99) standards for secure industrial automation and control systems. The ISA99 standard provides valuable guidance that is applicable to the implementation of a secure architecture.

At Eaton, cybersecurity is an integral consideration within our product design process. We developed strict protocols for the people, processes and technologies within our Secure Development LifeCycle process (SDLC), the program that integrates security protocols at every phase of product creation. SDLC includes threat modeling, training, requirement analysis, implementation, verification, deployment, ongoing support, and maintenance. These processes are robust and support secure products and services for even the most sensitive applications and installations.

Connected technologies are changing the face of the electricity delivery system. Traditionally, electrical systems were controlled through serial devices connected to computers via dedicated transceivers with proprietary protocols. In contrast, today's control systems are increasingly connected to larger enterprise networks and the cloud, which can expose these systems to vulnerabilities typically found in IT systems.

To protect important assets, organizations should take cybersecurity threats seriously and meet them proactively with an approach specific to organizational needs, while taking advantage of the latest updates to technologies by leveraging the security built into the leading cloud environments.

Conclusion

End-users across nearly every industry are in a constant battle to meet challenging and sometimes competing demands. They are at the heart of an increasingly digital economy and their success depends on "always on" power — yet they're under constant pressure to reduce energy usage. They must balance aging infrastructure with constrained budgets and the desire to make systems smarter, safer, and more responsive than ever before.

There are powerful solutions to these challenges found within the connectivity and intelligence of foundational electrical components such as circuit breakers. Consider the application of intelligent circuit breakers installed in the data center of a Midwestern U.S. university. With built-in intelligence and communications, the circuit breakers provided critical new functionality in ways previously unimaginable.

The facility manager and maintenance staff are now able use the circuit breakers' communications for remote operation — keeping personnel outside of the arc flash boundary to enhance safety. Meanwhile, the Ethernet-based communication enabled by the circuit breaker trip unit provides system wide communications without the additional time and expense of dedicated wiring.

Additionally, the intelligent circuit breakers are advancing maintenance and uptime by enabling troubleshooting and the ability to quickly identify the root cause of power system problems so that power can be quickly restored.

For example, a ground fault condition was recently detected at the university data center and the intelligent circuit breaker trip units alerted staff to the condition via new alarms. The data center staff was able to access current and historical power system data to identify and locate the problem before rapidly addressing the issue to restore power.

With the ability to set alarms and access historical data, the facility staff is better able to identify and address power system issues without the need for extensive investigating and troubleshooting. The real-time and historical data analysis provided through the intelligent circuit breakers is not only helping the university respond to system faults and failures, it is also allowing them to improve their maintenance operations by giving them the data to address system issues before an outage even occurs.

At Eaton, we've embraced the digital world and our place in it to rethink innovation. We're leveraging technology to improve our customers' power management systems with digital tools that drive productivity, safety, reliability, and energy savings. Whether it's the manufacturing floor, electric grid, buildings, healthcare facilities, transportation, or in the home, these intelligent and communicating electrical system building blocks generate the insights needed to help make smarter decisions, each and every day.

About Eaton

Eaton delivers a range of innovative and reliable indoor and outdoor lighting solutions, as well as controls products specifically designed to maximize performance, energy efficiency, and cost savings. Eaton lighting solutions serve customers in the commercial, industrial, retail, institutional, residential, utility, and other markets.

Eaton's electrical business is a global leader with expertise in power distribution and circuit protection; backup power protection; control and automation; lighting and security; structural solutions and wiring devices; solutions for harsh and hazardous environments; and engineering services. Eaton is positioned through its global solutions to answer today's most critical electrical power management challenges.

Eaton is a power management company with 2017 sales of $20.4 billion. We provide energy-efficient solutions that help our customers effectively manage electrical, hydraulic and mechanical power more efficiently, safely and sustainably. Eaton is dedicated to improving the quality of life and the environment through the use of power management technologies and services. Eaton has approximately 96,000 employees and sells products to customers in more than 175 countries. For more information, visit Eaton.com.

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Authors

Joel Benzing received his Bachelor of Science degree from North Carolina State. He has been with Eaton for over two decades in roles spanning engineering, product and marketing management for relays, motor control and switchgear. Joel Benzing is currently the marketing manager focusing on meters and relays at Eaton.

Robert Griffin has a Master of Business Administration from Carnegie Mellon University Bachelor of Science degree from Bucknell University. He has been with Eaton since 2003 in leadership roles spanning the manufacturing, supply chain and marketing functions and is now the Global Product Line Manager for molded case circuit breakers and air circuit breakers at Eaton.

James Lagree received a Master of Science degree in electrical engineering from the University of Pittsburgh and a Bachelor of Science from Rochester Institute of Technology. He started his career with the Westinghouse Electric Corporation as a design engineer working at the corporate Research and Development Center and Electrical Components Division. He has been with Eaton since 1994 and is now a chief engineer for the Power Components Division. Jim Lagree has been a member of IEEE for 38 years and member of the IAS, PES, IE and Engineering Management Societies. He was chair of the Pittsburgh IEEE section for 2016. He is listed as an inventor on 27 patents.

Lyle Sprinkle holds a Master of Business Administration with an International Marketing focus from the University of Texas at Dallas and an Electrical Engineering degree from Georgia Tech. He has held product management, marketing, and engineering roles at Honeywell, Vocollect, an industrial speech-recognition start-up, Harris Corporation, and Alcatel.

Through his career, he has architected and brought numerous cutting-edge solutions to market around the globe in wireless applications, mobile computing and networking spaces. Lyle Sprinkle is director of meters, relays and IoT Solutions in the Power Components Division at Eaton. He leads an exciting organization in the advancement of new IoT solutions to dramatically improve power system monitoring and reporting for industrial and manufacturing customers.

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