Life Is On | Schneider Electric

# Power management for a changing world

by Tony Hunt


## Executive summary

The changing world of energy is making it increasingly challenging to optimize power reliability, energy costs, and operational efficiency in critical power environments such as hospitals, data centers, airports, and manufacturing facilities. Utility power grids are getting more dynamic, facility power distribution systems are becoming more complex, and cyberattacks threaten network stability. More competitive pressures and environmental regulations are pushing expectations for energy efficiency and business sustainability higher than ever. Addressing these challenges requires new digital tools designed specifically to enable faster response to opportunities and risks related to power system reliability and operations.

## Introduction

In recent years, teams managing medium and large sized facilities have recognized that energy represents a significant line item in their operational costs. Many have also experienced how the quality and reliability of their electrical power impacts operational uptime and, in turn, has negative impacts to their bottom line.

Therefore, many organizations have established power and energy management programs. A variety of information and analysis tools are now available that help facility teams use a balanced approach in mitigating risks to every aspect of their power supply, from energy efficiency to power quality (PQ) and reliability.[1]

However, for facilities with critical power needs – such hospitals, data centers, airports, and industrial plants – ensuring high power efficiency and availability remains a very challenging prospect. There are many reasons for this:

**Figure** 1

*Hospitals, data centers, and other critical power facilities are faced with increasing challenges in maintaining power reliability and efficiency as the global energy landscape evolves.*

- A more dynamic grid: Utilities are adding renewables and other distributed energy sources. In the longer term, this promises to help improve grid stability and efficiency, but integrating green energy is causing challenges in some parts of the world, such as Germany[2] and Australia[3], the latter of which is seeing an increased risk of blackouts. Another risk to grid stability is periods of high demand, especially an aging transmission system is finding it hard to keep up. For this reason, many grid operators continue to offer demand response programs to reduce stress on the transmission network. Taking advantage of these programs can offer significant paybacks for large energy users, but it requires careful management of loads and onsite generation assets. Finally, the risk of widespread power outages due to extreme weather is growing. If we combine the Atlantic and Pacific regions, from January to the middle of September 2017 there have been 28 named systems. This is outpacing the previous busiest hurricane seasons in 2012 and 2005[4].

[1] Schneider Electric, 'Mitigating Risk Using Power Management Systems', June 2017

[2] MIT Technology Review, 'Germany Runs Up Against the Limits of Renewables', May 2016

[3] Daily Caller, 'Australia Considers Banning Wind Power Because It's Causing Blackouts', July 2016

[4] Quartz, 'The 2017 hurricane season is on track to break the record for the most named storms', September 2017

- **More complex power distribution systems**: At large facilities, plants, and campuses, power distribution systems typically evolve over time to accommodate more loads. This can either be more dispersed loads or higher load densities within the same footprint. Today, many of these loads are increasingly power sensitive, including automation systems, variable-speed drives (VSDs), computers, data servers, and communication networks. Many types of loads can also be the source of potential PQ issues. For example, excessive power harmonics can be produced by electric arc furnaces, inverters, DC converters, switch-mode power supplies, AC or DC motor drives, and variable speed drives. Lower power factor can be caused by large numbers of motors. It is also becoming common for large sites to include onsite generation, either for power backup, 'peak shaving' to avoid demand penalties, or to consume self-generated renewable energy when it's most economical. Onsite generation often paired with energy storage creates a facility or campus microgrid that can optimize costs and reliability, even 'islanding' itself in the event of a complete grid blackout. But managing this effectively requires advanced levels of monitoring and control intelligence.
- **More competitive forces and shareholder pressure**: Every organization is tasked with maximizing productivity and cutting operational costs. Businesses are also using operational efficiency as a competitive advantage, turning reduce costs into greater profits. Energy plays a big role in this equation, as power reliability has a direct influence on productivity, while equipment maintenance and energy costs impact the bottom line.
- **More regulatory requirements**: Large facilities are continuing to face stringent energy-related emissions regulations. Finding ways to reduce energy consumption can help, as well as supporting corporate sustainability goals. Companies also need to be aware that the products and solutions they buy comply with the latest hazardous materials standards (RoHS, REACH).
- **More cyberattacks**: Organizations experience increasing numbers of cyberattacks every year. This includes power utilities, and the consumers of their output; all contributing to potential business instability. Every connected system within a facility should now be considered a potential target, including the power distribution system.

Ensuring a reliable and efficient energy supply in the face these challenges requires more data, securely and continuously delivered from more places across the power infrastructure. However, this greater amount of data represents increased complexity for facility teams to manage going forward. For organizations that lack the in-house expertise and resources, this can be a significant burden.

To keep up with this changing landscape, new kinds of power management tools are emerging that deliver:

- **Connected intelligence** to reveal every risk and opportunity
- **Highest possible metering accuracy** for greater precision and certainty
- **Modular, customizable platforms** to adapt to changing needs
- **Cybersecurity best practices** to protect the power network
- **Simplified power quality analysis** using embedded intelligence
- **Smart power event analysis** to reduce response time

The following sections discuss each topic in more detail.

## Connected intelligence

As global energy consumption continues to rise, energy is becoming more decentralized and decarbonized. While demand is estimated to increase by 70% by 2040[5], 50% of new energy generation capacity will be represented by solar and storage by 2030[6]. Recognizing that there is huge untapped potential for energy efficiency, governments are introducing policies to promote climate-friendly buildings while renewable energies are becoming more mainstream and cost-effective.

In answer to these trends, the way we manage energy is changing. Power distribution is becoming more digitized, aiding the transformation to smart buildings and factories. Due to less and less tolerance for downtime and more ambitious efficiency and sustainability goals, organizations are seeking smarter tools offered by new digital power architectures. With more complex and sensitive loads and generation to manage, regulations and standards to comply with, and hidden opportunities to leverage, intelligent power systems are giving facility teams simpler ways of understanding their electrical systems that enable fast and effective decisions.

Gaining this intelligence requires greater levels of connectivity in buildings and factories. This trend has already begun. The Internet-of-Things has now been fully extended to the facility infrastructure, with more and more smart devices being connected to software systems and the cloud. In fact, analyst firm Memoori estimates the total number of connected devices across all categories of smart buildings will reach over 10 billion by 2021[7]. Analogous to the evolution of smart automation in building management systems, power distribution has evolved to include a network of connected products with embedded intelligence.

**Figure** 2

*Connected devices continuously deliver energy, power quality, and equipment status information to operations and maintenance teams wherever they are.*

Smart metering device functionality ranges from a few basic energy measurements to hundreds of power and energy measurements, data logging, alarming, and advanced power quality analysis and equipment status monitoring. Smart metering also comes in many shapes and sizes from dedicated power meters to embedded

[5] IEA, "World Energy Outlook 2015 Factsheet"

[6] Bloomberg New Energy Finance, "New Energy Outlook 2016"

[7] Memoori, "The Internet of Things in Smart Commercial Buildings 2016 to 2021", Q3 2016

metering modules inside other devices such as circuit breakers, protection relays, or equipment controllers and drives.

## Green and robust

The new era of power distribution brings with it a new focus on environmental standards compliance. Most devices are now required to comply with international directives and regulations, such as RoHS and REACH. that control the substances used in products and the chemicals used to manufacture them.

Many manufacturers also offer metering and monitoring products that are designed for use in harsh environments. This can include protection against EMC radiation, as well as IP ratings to prevent ingress of moisture, dust, gases, and other pollutants.

Embedded metering in smart equipment is cost effective and convenient for basic monitoring applications such as energy usage. For more advanced applications, such as power quality monitoring and power event analysis, advanced power quality meters are required.

In the digital architecture of modern power management systems, smart equipment and power meters are designed to share their information with the others layers of the architecture:

1. **Edge control.** Power management applications provide monitoring and control functions for local operators.
2. **Cloud-hosted analytics.** Advanced analytics and tools enable service engineers to provide insights and recommendations to end users to help keep their electrical distribution and power management systems performing optimally.

At both of these levels, mobile devices are playing an increasingly important role, especially for operations and maintenance teams. Data and alarm notifications can be accessed by any authorized person, anywhere they are, at any time. Real-time updates, graphic dashboards, and deep analytic views can be delivered from local or cloud-hosed apps, or even from embedded web servers within individual smart devices. This is helping both in-house and contracted service teams to discover risks and respond.

Traditionally separate facility systems are also becoming more tightly integrated. Communications and database standards allow data from power distribution systems to be shared more easily with building management (BMS) or process automation systems (PAS), and vice versa. Some vendors are now providing power management software as an embeddable plug-in to the BMS or PAS. This approach is typically superior in terms of cost and capability compared to, for example, using generic software tools to engineer limited power management features in the BMS or PAS software. Having power management capability integrated in this way can help both engineering and building management teams collaborate more closely on shared efficiency and reliability goals, while giving each team a broader perspective.

Ultimately, these advances in power intelligence and connectivity are making possible more information from more places, accessible in more ways than ever before. The challenge for facility and services professionals is to make sense of this potential data overload. More powerful tools are needed to help teams not only turn data into information, but also:

- ensure the electrical network is fully protected from cyber threats
- decypher the relevance of the information
- discriminate between levels of importance and urgency
- analyze and isolate the source of risks faster
- ensure that no opportunity is overlooked or money wasted
- power management capabilities keep up with the pace of change

Fortunately, new capabilities are emerging that will help teams more easily understand and act on the information from their power distribution network, while having the peace of mind that their information system is secure and dependable.

## Highest metering accuracy

A power management system not only helps optimize power quality and reliability in critical power environments, it also delivers the facility-wide energy consumption data needed to find energy waste, improve energy efficiency, and lower electricity costs. There are a broad range of initiatives that can help achieve these goals, some of which are listed in Table 2.

**Table 1**

*Common energy efficiency and cost management applications*

| Application | Description |
|---|---|
| **Validating utility billing** | Use ‘shadow’ metering to track energy consumption at the facility or campus service entrance to help uncover utility billing errors (typically the application with fastest payback on a power management solution). |
| **Energy cost accounting** | As part of a standard Measurement & Verification program, for example the M&V 2.0 guidelines proposed by the U.S. Department of Energy[8]:<br>• Gain insight into opportunities where energy waste is identified and inefficient usage patterns emerge<br>• Track energy cost to date for each billing cycle to help gauge future cost impacts<br>• Isolate cost drivers<br>• Plan actions<br>• Validate cost savings |
| **Power factor management** | Mitigate penalties on utility bills due to lagging power factor by metering active and reactive power. |
| **Daily active management** | • Alarms to alert staff and operators of energy consumption exceeding defined thresholds<br>• Determine and implement energy setbacks using either the power management or building automation system |
| **Cost allocation** | Submeter tenants, departments, or processes and allocate (sub-bill) energy costs to encourage energy efficient behavior. |
| **Capacity analysis** | Meter dynamic energy consumption on all mains, feeders, and major loads to uncover extra power distribution system capacity that could be safely leveraged, avoiding the need for infrastructure upgrading. |
| **WAGES metering** | Going beyond managing electrical energy use by integrating the metering and management of all other utilities including water, compressed air, gas, and steam. |
| **Energy intensity and KPIs** | Measure energy usage against an organization’s business performance, e.g. energy vs. units of output. Predict energy demand to optimize operational costs by normalizing energy consumption data against factors such as:<br>• Temperature<br>• Amount of product output<br>• Shifts<br>• Batch or work order |

[8] Energy.gov, “Leveraging the Power of Data Analytics for Savings Measurement & Verification”, April 2017

## Accuracy standards

Standards organizations in different parts of the world establish performance criteria for electricity meters, including accuracy class designations. These standards give buyers of meters a uniform method of evaluating competing products and obtaining the proper meter for the particular need.

For example, the ANSI 12.20 standard establishes the acceptable performance criteria for 0.2 and 0.5 accuracy class electricity meters for North America. The current standard requires a list of 38 separate tests to be passed before a meter manufacturer can claim compliance.

For all of these applications, the accuracy of the energy metering devices used will directly impact analytic accuracy. The higher the accuracy, the more confidence facility teams can be in the information and the more savings opportunities will be uncovered.

For example, for shadow metering, it's recommended that the 'check' meter used meets a minimum Class 0.2 to align with the accuracy of the billing meter used by the energy provider. Class 0.2 represents a verified 0.2% accuracy for energy measurements.

However, facility and energy managers need to be aware that new ANSI and IEC standards for Class 0.1 accuracy may be soon be implemented for billing or cost allocation applications. Fortunately, a new breed of high accuracy energy metering products is being introduced that comply with the Class 0.1 standard, redefining the standard for accuracy at twice the precision
'n of existing energy standards.

When choosing an energy meter, it is important that the product's accuracy has been third-party verified and complies with all aspects of the accuracy standard. Standards typically require a list of tests that go well beyond energy accuracy to account for a wide range of influencing parameters. These can include changes in load current, power factor, temperature, and harmonic distortion, with multiple test points over a wide dynamic range. [9]

If the meter is to be used for utility service verification, it should also offer on-board data logging and high resolution (256+ samples/cycle) metering. The meter and/or system-level software must also provide a billing module configured to match the utility tariff schedule.

An increase in metering accuracy will also provide increased precision and confidence in all other energy consumption and cost calculations, helping with initiatives such as utility contract negotiations, and more accurate reporting on sustainability and energy-related emissions targets.

[9] L. A. Irwin, Schneider Electric, "A high accuracy standard for electricity meters", April 2011

## Modular, customizable platform

As the worlds of energy and automation evolve, power management capabilities need to keep up. For example:

- As microgrids and renewable energies become more ubiquitous within large mission-critical facilities, power measurement and analysis will become even more necessary. Microgrids use automated control to balance energy generation and demand in real time, so it's important to keep on top of active/reactive power, frequency, voltages, currents, and power quality parameters.[10]
- As the 'Industrial Internet of Things' and 'Industry 4.0' smart manufacturing trends become more established, there will be greater numbers of intelligent devices – including new 'smart machines' – and greater levels of connectivity throughout manufacturing and processing plants. Keeping all of this power-sensitive equipment running will require a vigilant power monitoring program.[11]

As these and other system technologies evolve, there will be a need to measure and capture new kinds of conditions and interactions in more places within the facility, campus, or plant power infrastructure. Power management solutions need to adapt to these new requirements.

Some of the newest advanced meters and power management systems offer modular designs that enable adaptation to changing needs. Meter capabilities can be augmented using downloadable firmware upgrading, as well as field-replaceable hardware modules such as I/O options. Those with modular firmware architectures can have their internal functions customized for different measurements or unique applications. Many also offer shared accessories across different models, simplifying selection, inventory, and installation.

At the application level, power management software is also becoming more modularized. This enables facility teams to add on specific analytic functionality as required, such as sub-billing module or an advanced PQ analysis module.

Power management systems have also become more scalable. This is partially due to the trend in IoT-enabled communications. But advances in network configuration tools and database management are making it simpler to add devices and connections when and where required. For example, IPv4 and IPv6 Internet protocol support with DHCP offers the ability to connect to local and wide area networks with automatic IP address acquisition.

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[10] Schneider Electric "How New Microgrid Technologies Enable Optimal Cooperation Among Distributed Energy Resources', March 2017

[11] Schneider Electric, "Understanding Smart Machines: How They Will Shape the Future", October 2015

## Cybersecurity best practices

A report by Business Insider estimates that “nearly $6 trillion will be spent on IoT solutions over the next five years. Businesses will be the top adopter of IoT solutions.”[12] With greater numbers of connected devices comes the higher risk of cyberattacks.

“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.”[13]

Power distribution systems are one of the mission critical infrastructures that need comprehensive protection; this includes the power management network layer. Cyber-savvy manufacturers follow a disciplined secure development process that provides security training to architects, developers, and testers, adheres to security regulations/best practices, including completion of threat model, architectural reviews, secure code practices, and executing extensive security testing.

**Note:** for a comprehensive discussion of cybersecurity best practices for power monitoring and control systems, potential risks posed by hacking, and strategies to help mitigate, see the white paper “Securing Power Monitoring and Control Systems”.

The following are some of the cybersecurity features implemented by the newest, most advanced power management systems and components:

1. **Digitally signed and encrypted firmware**: such vendor firmware indicates genuineness of downloads, providing assurances that the content is as originally intended, from the identified source/vendor, for use in prescribed devices.
2. **Per-user security permissions and passwords**: limits system access to only authenticated users, in authorized role categories; supports user accountability allowing sufficient scope of access to support specific job functions.
3. **Security logging**: tracking all login attempts (including successful or failed attempts), user actions within the system,-with event log push to Microsoft SysLog.
4. **Trusted Platform Module (TPM):** a specialized chip (crypto processor) on an endpoint device that stores encryption keys specific to the host system for hardware authentication; supports device genuineness schemes.
5. **Achilles Test Platform (ATP)**: a communications robustness test platform used by leading mission critical manufacturers to validate the ability of a device/system to stave off Denial of Service attacks; certification available to demonstrate compliance to ATP performance criteria.
6. **Penetration (‘pen’) testing**: an authorized simulated attack on a computer system, application software (PC-based or mobile), or embedded device, to evaluate the security robustness and resilience of the test subject.

[12] Business Insider, “Here's how the Internet of Things will explode by 2020”, August 2016

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

# Simplified PQ analysis

*"In 2006 the Leonardo Power Quality Initiative pan European survey reports that around 30% of the most sensitive industry sectors many incur a PQ cost of about 4% of their turnover."*

***The Cost of Poor Power Quality, Leonardo Energy***

The quality of power delivered to loads throughout a facility has a direct impact on operational efficiency and reliability. Poor power quality can cause malfunction of machines and devices. Over time, this can also damage the equipment and reduce its overall lifespan. Chronic power quality issues such as high current harmonics cause overheating of conductors and windings, which can lead to catastrophic failure and even fires. In the end, poor power quality can have a significant business impact in the form of unplanned downtime, as well as premature equipment failure and replacement.

It's estimated that approximately 80 percent of power quality incidents are generated inside facilities, caused by equipment such as variable speed drives, capacitor switching, large motor starts, and computers. The other 20 percent come from the electrical distribution grid. Though many electricity providers promise up to 99.99 percent energy availability, that still equates to about 52 minutes of interruptions every year.

Most types of loads are designed to tolerate a small amount of power quality anomalies. Above that level, the reliability and longevity of power, process, and computing equipment are impacted. For sensitive processes, the quality of the resulting product can also be affected. And for continuous processes, there are the costs of wasted product, retooling, and restarting.

There are many characteristics that define the quality of power. In an ideal world, the voltage and current waveform delivered by the power distribution system would be perfectly symmetrical sine waves. But perfectly 'clean' power is never a practical reality, since so many things can affect it.

Power quality issues are typically hidden risks, in that they often remain invisible until a failure or malfunction occurs. This is why power management devices and systems have, for many years, featured power quality metering, monitoring, logging, and analysis capabilities. These are designed to capture data on a continuous basis, alerting an operations team to any conditions or events that could pose a risk to equipment or processes. The recorded data can also be used to verify that the quality of electrical power provided by the electric utility meets the contractual obligation or standard.

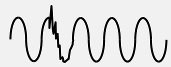
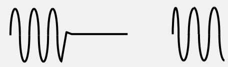
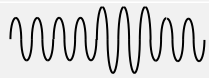
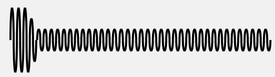
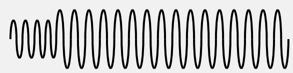
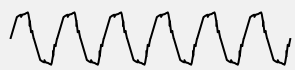
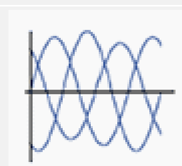
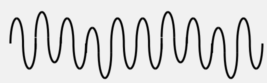
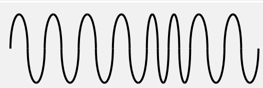
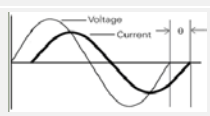
Though the power quality requirements for different kinds of organizations might differ, the types of characteristics that need to be tracked and recorded by power quality monitors are typically the same. These are listed in Table 1. For a more detailed description of power quality characteristics, causes, effects, and management strategies, refer to the Schneider Electric white paper "A Framework for Implementing Continuous, Iterative Power Quality Management"[14].

Though it is essentially that all of these power quality characteristics be continuously measured, captured, and recorded, the resulting information also needs to be interpreted to be able to identify risks and determine appropriate actions. Due to the amount and complexity of the data, if a facility team does not possess power quality expertise, this can pose a substantial challenge.

[14] Schneider Electric, "A Framework for Implementing Continuous, Iterative Power Quality Management", May 2015

**Table 2**

*Common disturbances that impact power quality.*

| Disturbance category | Waveform | Effects | Possible causes |
|---|---|---|---|
| Transients |  | Equipment malfunction and damage | Lightning or switching of inductive / capacitive loads |
| Interruption |  | Downtime, equipment damage, loss of data possible | Utility faults, equipment failure, breaker tripping |
| Sag |  | Downtime, system halts, data loss | Utility or facility faults, startup of large motors |
| Swell |  | Equipment damage and reduced life | Utility faults, load changes |
| Undervoltage |  | Shutdown, malfunction, equipment failure | Load changes, overload, faults |
| Overvoltage |  | Equipment damage and reduced life | Load changes, faults, over compensation |
| Harmonics |  | Equipment damage and reduced life, nuisance breaker tripping, power losses | Electronic loads (non-linear loads) |
| Unbalance |  | Malfunction, motor damage | Unequal distribution of single phase loads |
| Voltage fluctuations |  | Light flicker and equipment malfunction | Load exhibiting significant current variations |
| Power frequency variations |  | Malfunction or motor degradation | Standby generators or poor power infrastructure |
| Power factor |   | Increased electricity bill, overload, power losses | Inductive loads (ex. motors, transformers...) |

## PQ Standards

International power quality compliance standards define the acceptable limits and interpretation of a range of PQ phenomena.

### EN50160

- Power frequency
- Supply voltage magnitude
- Flicker
- Supply voltage dips
- Short and long interruptions
- Temporary overvoltages
- Supply voltage unbalance
- Harmonic voltage
- Inter-harmonic voltage
- Mains signaling voltage

### IEEE 519

All of the above, plus:

- Supply voltage swells
- Transient voltages
- Current harmonics
- Rapid voltage changes

Many power management systems now offer a variety of visualization tools to simply this analysis, including trends, charts, counters, and statistics.[15] In the newest of these solutions, onboard PQ analysis at the device level provides a pre-evaluation of system stability at each critical node. Operations and maintenance personnel are given answers, not just data, making it faster and easier to understand the health of the power system.

In many parts of the world, government regulations stipulate that electric utilities must supply “high quality” electrical power such that the power delivered to the consumer meets a number of quality criteria. The two most common standards, EN50160 and IEEE 519, have wide adoption in many regions. World-class power management systems use advanced power quality compliance monitoring devices

[15] Schneider Electric, “Metering Your Way to Better Demand Side Power Quality”, May 2017

and factory-engineered power quality compliance tracking and reporting tools. With the right equipment and software in place, understanding if your power supply is in compliance to EN50160 and IEEE 519 standards should be easy to do with simple pass/fail indicators for each of the compliance categories.

Modern power management systems provide several options for accessing power quality information from metering devices. These include:

- Using advanced, system-wide software applications
- Using a web browser to view web pages hosted by individual devices
- Viewing data on the front panel display of a device

Making use of power quality information requires specialized user interfaces designed specifically for viewing and analyzing power quality data. Generic visualization tools such as tables, trends and charts are not sufficient. Traditional power quality visualization tools include waveform viewing and analysis, harmonic histogram viewing and analysis as well as displaying voltage disturbance events on CBEMA/ITIC or Semi F47 voltage tolerance curves.

**Figure** 3

*Typical web-based, power quality CBEMA curve provided by an advanced power quality meter, showing simplified pass/fail indicators.*

One company has gone beyond using just the classic power quality diagnostic tools and is now making it easier than ever to determine where disturbances are coming from without ever looking at a waveform. Schneider Electric is the only manufacturer in the world that offers a power meter that automatically analyzes every waveform it captures and indicates which direction the disturbance was travelling. This patented technology, called Disturbance Direction Detection, makes it incredibly easy to determine if voltage disturbances are coming into a facility from the grid or if they originated from inside the building. With a network of these power meters and Schneider Electric's world-class power management software, it is now possible to see how a disturbance flowed through the electrical distribution system. This kind of insight is an invaluable first step for diagnosing power quality problems and saves a tremendous amount of time.

In additional to momentary disturbances, electrical systems can also suffer from periodic or chronic issues such as voltage unbalance or voltage distortion that cause the flow of current harmonics. Power management software is specially designed to continuously monitor and track these parameters and notify personnel if the condition of the power supply is degrading or starting to fall outside a prescribed set of limits.

With these powerful tools, facility teams can more easily identify PQ issues that may be the cause of power disruptions, equipment malfunction, or damage. This insight can help in decisions regarding what mitigation techniques might need to be deployed, such as PF correction, harmonic filtering, VAr compensation.[16] Facility personnel can also receive advance notification of potential anomalies to help avoid problems. PQ characteristics can be reported over time to support continuous improvement efforts and to ensure the energy provider continues to meet contractual obligations.

However, with the increasing complexity of electrical systems, loads, and processes, isolating the source of a particular power quality problem has become more challenging. New capabilities are becoming available that will reduce the time needed to analyze root causes and get the facility back up and running.

## Power event analysis

When a circuit breaker trips and instantly a part of a facility is in the dark and without power, or when the lights suddenly dim and immediately equipment begins to malfunction, what is the fastest and most efficient way to resolve the problem and get the facility back up and running? Was the issue related to a voltage disturbance or poor power quality? Specifically, what caused the problem in the first place and how did it cascade out of control to lead to such significant unplanned downtime? These questions can only be definitively and effectively answered when a modern, high definition, purpose-built power management system is in place.

Such a system must have a network of advanced power quality monitoring devices capable of high-speed disturbance capture with disturbance direction and clock synchronization using ‘Precision Time Protocol’. It also requires sequence-of-event recording devices capturing high-definition events and status conditions from surrounding equipment for operational context. The fundamental reason why all of the devices capturing operational status data must be time synchronized with the power quality meters is because electrical disturbances travel incredibly fast. So, this is the only way to ensure that the sequence of events is captured in the correct order of operation. Without the correct design and power monitoring infrastructure, power event reconstruction would yield uncertain results with the actual duration between events and order of operations remaining in question.

Capturing all power system events in the right order with the correct timing of operation provides the foundation for thorough and accurate power system event analysis. However, sifting through and interpreting vast amounts of event data can be tedious and very time consuming. Fortunately, some power management software vendors are now providing the means to define a collection of specific events as a single alarm and then aggregate multiple alarms that occur within a given time period into a single incident. This intelligent approach to alarm definition and aggregation, combined with advanced alarm filters, dramatically streamlines alarm management work flow and saves a significant amount of time for system operators.

[16] Schneider Electric, “Identifying Power Quality Issues and Implementing Solutions”, June 2016

One of the pioneers in power management systems, Schneider Electric, is now taking root cause analysis and power system event reconstruction to the next level by offering a sophisticated graphical event analysis application that is the first of its kind. This specialized software interface plots power system events graphically on a timeline in the context of other operational events. The interactive nature of the application makes it incredibly easy to visualize what happened and provides the contextual information necessary to quickly draw conclusions about cause and effect.

Knowing exactly what happened during an incident is invaluable on several different fronts. This knowledge is vital for re-establishing normal operations as quickly and safely as possible after an incident occurs, but is also crucial for mitigating future occurrences of a similar incident. This information can also be useful for proving who is liable for damages and may even be used for insurance or warrantee claims.

**Figure** 4

*Smart alarms and root cause analysis tools help identify, prioritize, and isolate sources of power quality events.*

Note: for a comprehensive discussion on how Power Quality data enhances power networks, please see the white paper "Real experience using power quality data to improve power distribution reliability".

## Conclusion

Power monitoring systems have been available for many years, providing visualization tools and decision support to facility teams who manage power and energy-related risks. But the energy world is rapidly evolving and electrical distribution systems are becoming increasing complex., Which means large and critical facilities need to be equipped with equally sophisticated power management tools designed for modern, digitized environments in order for their business to remain as competitive and profitable as possible.

Increased metering accuracy is also making higher precision energy analysis possible, saving more costs and providing higher confidence when executing energy management initiatives and validating utility bills. Choosing a meter that is utility approved will ensure highest quality and parity with how the energy provider is billing the customer.

Modular architectures are enabling the capabilities of metering devices and software to evolve more quickly and easily to respond to new challenges.

The newest cybersecurity practices are protecting facility power infrastructures that are taking advantage of increased levels of connectivity between devices, equipment, and applications.

Finally, advancements in power metering technology combined with the emergence of highly specialized power management software applications, has made it simpler than ever before to identify and manage power quality risks and opportunities. Modern power management systems are now able to capture, analysis and present complex, high resolution power system information in such a way that facility management teams can easily visualize and quickly reconstruct exactly what happened during a power system incident. Without such tools and technology in place, companies that operate large and critical facilities are exposing themselves to unnecessary risks related to business continuity and efficiency.

## About the author

**Tony Hunt (MSc, CEM, CPQ)** works for Schneider Electric as a global marketing manager specializing in bringing power management applications to segment-specific facilities like data centres, healthcare, industry, infrastructure, and large buildings. As a Certified Energy Manager and a Certified Power Quality Professional with over sixteen years' experience in the field of energy and power management, Tony helped develop and deploy power management software modules designed to integrate with Building Management Systems and Process SCADA Systems. He remains an instrumental contributor to Schneider Electric's integrated power management software strategy.

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