Power Digitalization: Understand and Achieve Active Energy Management in Buildings

White Paper 503

Version 2

by Tony Hunt

Executive summary

Most public, commercial, and industrial buildings are not energy efficient, representing an enormous untapped potential for decarbonization and sustainability efforts, as well as utility bill savings. Power digitalization plays a foundational role in active energy management and efficient facility operations. For existing buildings, this can be done by retrofitting electrical systems with smart devices and using energy and power management software that improves energy efficiency and reduces risk. This power digitalization investment helps facility management and maintenance personnel make better decisions, resolve issues more quickly, minimize downtime, and use less energy. In this paper, we define power digitalization for buildings, and describe a 3-step process to achieve it.

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Introduction

Today, industrial sites, public, and commercial buildings consume 63%[1] of the world's electricity and are responsible for 43% of global CO_2 emissions.[2] The vast majority of these facilities are energy inefficient, representing an enormous untapped potential for decarbonization and sustainability. And despite recent commitments of many countries, organizations, and corporations to achieve net-zero carbon emissions, there is still insufficient investment in creating sustainable buildings and a lack of effective energy-efficiency policies enacted.[3]

87% of energy industry professionals say digitalization is part of their company's strategy.

DNV GL

Digitalization and the Future of Energy 2019 Report

It is clear that electricity will play a much larger energy consumption role in the future than it does today. Buildings will not just consume power, but they will also produce, store, and share it. To handle the complexities of distributed generation, energy storage, EV charging, and connections to the smart grid, all buildings will need to have smart power systems connected to energy management software[4]. Due to the intermittent nature of renewables and effects of power conversion, managing power quality will also be important.

The impacts of a changing climate and an increasingly complex energy landscape are already becoming evident as electric utility companies struggle to deliver clean, stable, reliable power to their customers[5] and buildings and industrial complexes are experiencing more power disturbances than ever before.[6] Energy efficiency initiatives such as installing LED lighting and variable speed drives can also cause serious power quality problems inside buildings. And yet, **most facilities operate without any information about their electrical systems and the power flowing through them**. It is estimated that >90% of all electrical distribution equipment is not connected to software.[7]

"We live in the information era, but we rarely use building data for operation. It's like driving a car without a speedometer."

Dietmar Geiselmann, German Sustainable Building Council (DGNB)

From: SMART AND EFFICIENT Digital solutions to save energy in buildings. 2019. PEEB Programme for Energy Efficiency in Buildings

Despite these trends, investment strategies for building renovations typically do not include retrofitting the electrical system or suggest upgrading to a smart power system.[8,9] The EU Commission *Directive on the energy performance of buildings* and EU *Commission Recommendation on building modernisation* mention the value of "building automation and electronic monitoring of technical building systems" but do not consider the electrical distribution system as a technical building system.[10,11] This is mostly due to the fact that electrical systems are not top of mind and have been largely ignored from a building management and smart building perspective.

In this paper, we raise awareness about the importance of "**power digitalization**" and the valuable role it plays in the new energy landscape. First, we present a short definition of power digitalization followed by an explanation of the process for achieving power digitalization in three simple steps.

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[1] Calculated from 2018 data from IEA based on Electricity final consumption by sector

[2] Adapted from 2020 Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. United Nations Environment Programme.

[3] Buildings - A source of enormous untapped efficiency potential from International Energy Agency (IEA)

[4] Net Zero Carbon Cities: An Integrated Approach. World Economic Forum report, January 2021.

[5] Managing the growing renewables crisis. A Micatu, ZPryme Survey Report, April 2021.

[6] Understanding the Cost to U.S. Business from Unmitigated Reliability and Power Quality Events. EPRI report. December 2020.

[7] Global estimates from Schneider Electric Field Services organization in 2020.

[8] U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE)

[9] Bloomberg. JLL - Seven ways to retrofit

[10] Commission Recommendation on building modernisation. Official Journal of the European Union. 7 June 2019.

[11] Directive on energy performance in buildings. Official Journal of the European Union. 30 May 2018.

Defining power digitalization

Digitization, digitalization, and digital transformation are popular terms that are often used interchangeably without much discrimination. Arc Advisory Group and I-Scoop provide good definitions of these terms and explain the differences.[12,13] In this paper, we are focused on the term, digitalization.

With respect to energy management and electrical systems in buildings, **power digitalization** is achieved when energy and power management system (EPMS) software is used to simplify tasks, streamline activities and automate processes. EPMS software collects energy usage, power events, and electrical asset performance information from sensors, power meters, protection relays, circuit breakers, and other smart power equipment such as uninterruptible power supplies and variable speed drives. The full potential of power digitalization is realized when the EPMS is connected to the cloud and integrated with other management systems such as building management, integrated workplace management, process SCADA, billing, accounting, enterprise resource planning (ERP), and enterprise energy management systems, as illustrated in **Figure 1**.

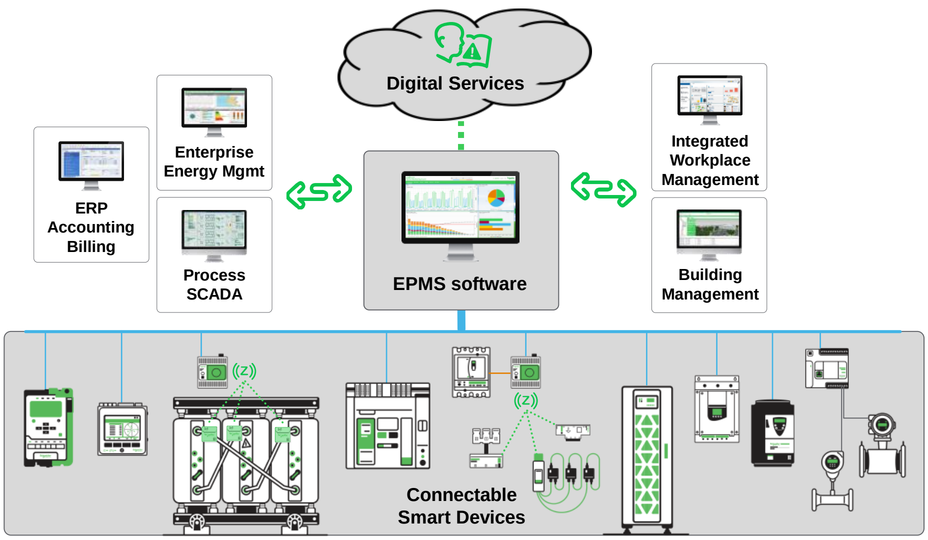

Figure 1
Overview of an EPMS

Buildings without digitalized electrical systems

"Digitalisation can improve energy efficiency through technologies that gather and analyse data to effect real-world changes to energy use"

IEA

https://www.iea.org/articles/energy-efficiency-and-digitalisation

All facilities depend on electricity. And for most buildings, it is the primary energy source that powers the lights, air conditioners, elevators, escalators, appliances, and every wall outlet and computer. Yet most organizations are still working blind, without visibility into their power usage, condition of their electrical infrastructure, and carbon accounting. If your electrical distribution network is not digitalized, the following questions become very difficult to answer satisfactorily.

- Is your electricity bill your only means to measure power usage?
- Do you know how building operations impact the charges on your electricity bill?
- Are your utility bills free from mistakes each month?
- Do you have a way to detect if power is being used unnecessarily?
- How do you measure carbon impact and energy savings? Is this automated?
- Do you have a way to show the occupants the energy usage in the building?
- Are you managing the loading on your circuits to maximize the capacity of your electrical system and prevent overloads which may trip a breaker unnecessarily?

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[12] ARC Advisory Group.

[13] I–SCOOP.

- How do you assess the condition of your transformers, breakers, UPS's or your backup generators?
- When there is a problem with a piece of equipment, how do you check whether it was caused by something electrical?
- Have you ever had a mysterious issue that may have been electrical, but the root cause was never confirmed?
- How do you determine when maintenance is needed for components of your electrical system?
- When a breaker trips, can you determine what happened leading up to the incident to determine what caused it?
- When there is a power outage, how do you gather the information you need to get the power back on and get things back to normal, quickly, and safely?

A lack of information about power usage and how the electrical system is behaving exposes facilities to a great deal of risk, including risks to safety, uptime, energy efficiency, operational efficiency, and compliance.[14,15] **The sections that follow focus on specifying solutions that help answer these questions.**

Three steps to achieve power digitalization

Power digitalization plays a fundamental role in facility energy management, power availability & quality, and electrical equipment maintenance. Achieving power digitalization is based on connecting smart sensors and communicating devices to EPMS software and consists of three basic steps: **Connect** – **Automate – Extend**.

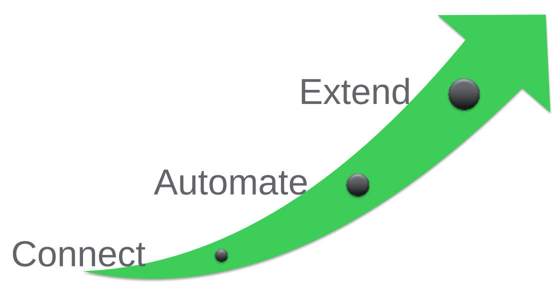

Figure 2
Three steps to achieve power digitalization

Step 1: Connect

The first step of power digitalization involves the collection of energy usage, power quality, and electrical asset performance data. There are many different types of devices that measure energy consumption and make power measurements available via data communication protocols. EPMS software is specifically designed to communicate with these types of devices for the purpose of collecting energy and power information. This data serves as the foundation for EPMS software to further process and make available as actionable information via specialized energy and power management web applications.

Check for existing connectable devices

Most facilities already have power measurement devices installed and equipment with embedded metering capabilities. Medium voltage (MV) switchgear will likely already have protection relays installed in the control cubicles. Sometimes MV panels have power meters installed as well. Low voltage electrical distribution panels may also contain digital devices that can measure energy and power usage,

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[14] Markus Hirschbold and David Kidd. *Mitigating Risk using Power Management Systems*. Schneider Electric White Paper.

[15] Markus Hirschbold. *Bringing critical power distribution out of the dark and into a safer, more reliable and efficient future*. Schneider Electric White Paper.

including breaker trip units and power meters. Power equipment such as automatic transfer switches (ATSs), uninterruptible power supplies (UPSs), generator control units, variable speed drives (VSDs) and motor control units usually have communication ports that can provide power measurement data. EPMS software can also get energy usage data from devices such as programmable logic controllers (PLCs), data concentrators, and remote terminal units (RTUs) that collect data from water, gas, electricity, steam, and heat meters using I/O (input/output) connections. Smart flow and heat meters have communication ports and so EPMS software can usually read data directly from those meters. **Figure 3** illustrates some common types of equipment that can be connected to EPMS software.

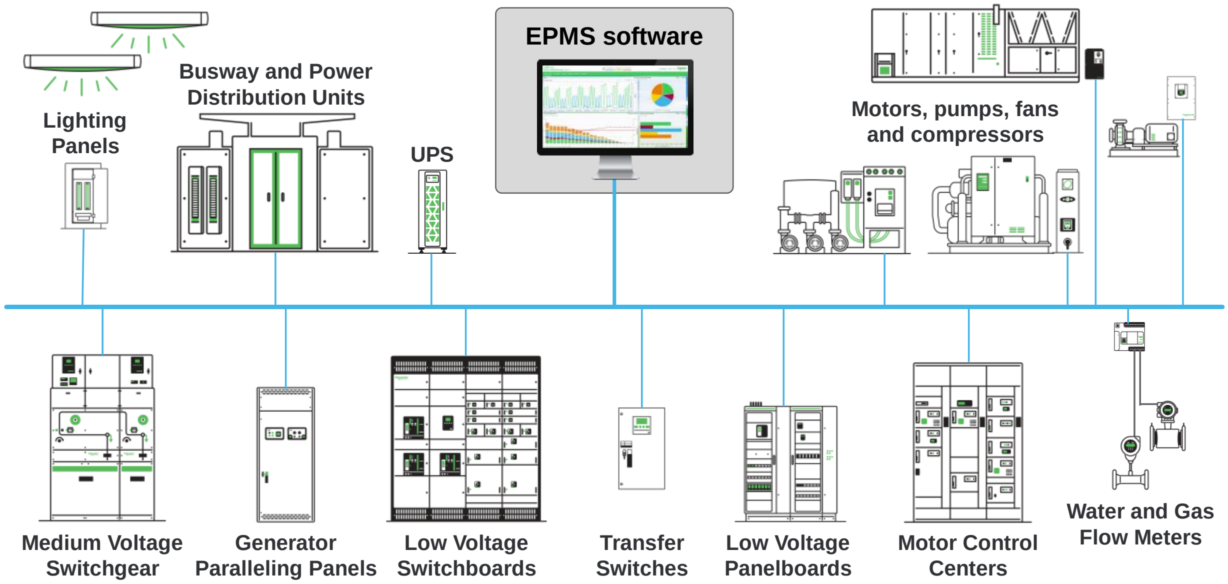


Figure 3
Common types of equipment that can be connected to EPMS software

For each connectable device that is identified, several things need to be verified:

- Make and model of device and date of manufacture or installation
- Is the device functioning correctly?
- Is the device still supported by the manufacturer?
- Is the device running the latest firmware?
- Does the device present a cybersecurity risk?
- What types of communication does the device support? Serial RS-485, Ethernet over twisted pair (e.g. 100Base-TX), optical fiber (e.g. 100Base-FX) or wireless (e.g. Zigbee)?
- Is the device already configured and communicating over an IT network?
- Is there already software connected to the device collecting information from it?
- Can the device communicate over Modbus protocol? If not, what data communication protocols does it support?

Serial ports can only support one connection at a time using a designated communication protocol. On the other hand, Ethernet communication ports will often support multiple simultaneous connections and multiple protocols. For each type of device, the manufacturer's technical documentation should be consulted to determine exactly what communication options are available.
This is a great opportunity to create an inventory that lists all the smart devices found in the facility. The document should include information such as device name, location, make/model, description, and communication configuration details.

Identify locations where additional power measurement is needed

Once an inventory of existing smart devices is compiled, determine if additional power metering is required. Many electrical panels will not be equipped with metering. Therefore, the first place to verify that suitable metering devices are installed is on the **main incoming feeder(s) to the facility**. This is where power meters can be used to check the quality of incoming power supplied by the utility. This is also the location where total facility consumption, power demand, and power factor can be monitored and used to check the electricity bill is correct each month. The best choice for monitoring the service entrance(s) to a site is a 0.1% accurate, power quality instrument (PQI). PQI meters are designed to correctly and consistently measure power quality in accordance with IEC 61000 4-30 and will remain accurate under a wide range of electrical and environmental conditions according to IEC 62586-1 and IEC 62586-2. For more information about these standards and power quality instruments, refer to white paper, *Power Quality Instruments (PQI): An Overview*.

It is also important to confirm that adequate metering is present on **all circuits supplying power to large assets and critical pieces of equipment**. A simple way to add metering to larger circuits is to install a rope-style power meter (see **Figure 4**) that uses Rogowski current sensors and wireless communications. This type of power meter is designed for retrofitting into electrical panels and is easy to install and commission.

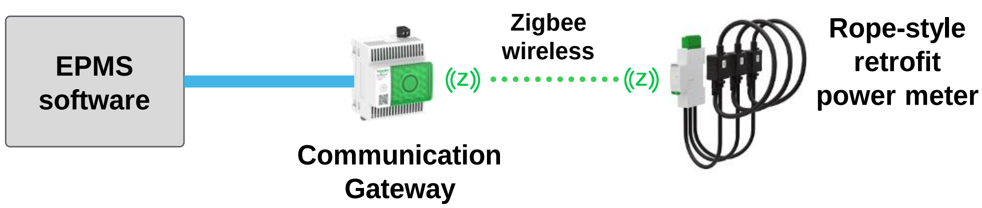


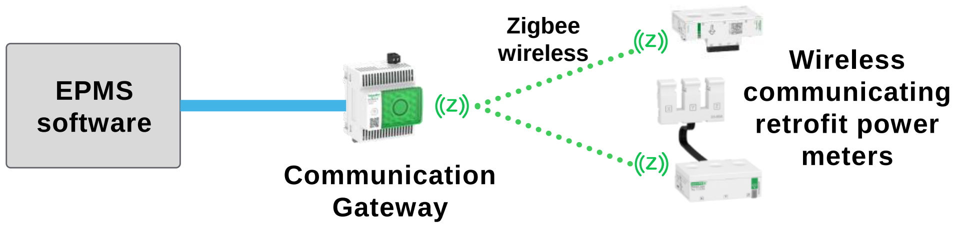
Figure 4
Rope-style retrofit power meter with wireless communications

For **circuits that provide electricity to power-sensitive equipment**, it is recommended to use power meters that can detect and capture high-speed, voltage disturbances and measure individual harmonics. If voltage sags occur frequently, then dynamic voltage restorer (DVR) equipment may be needed. If excessive harmonics are present, then active harmonic filters (AHFs) may be required.

Complying to building codes and regulations, adhering to energy efficiency standards, and achieving green building certifications **all require branch circuit power metering to be in place**. It is also a “best practice” in energy management to **monitor and report energy use by load type** (e.g. HVAC, lighting, refrigeration, appliances and power outlets) which also requires a high degree of submetering. For more information about this topic, refer to white paper, *Designing Electrical Systems for Future-proof, Energy-efficient Green Buildings*.

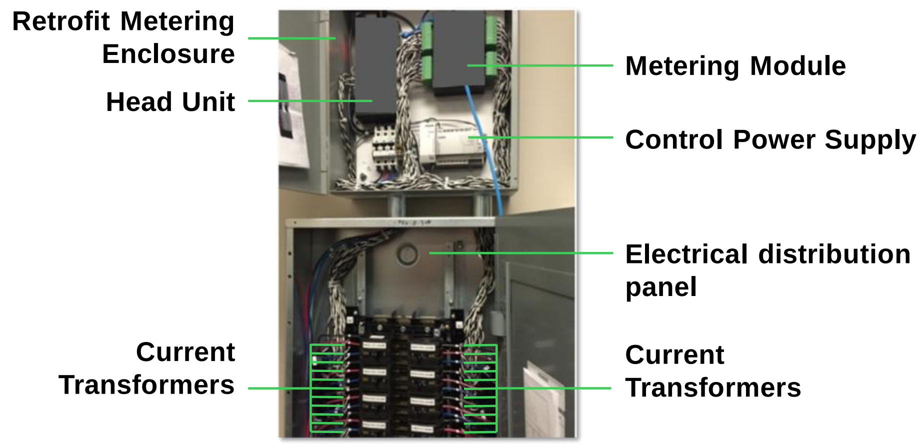
In industrial manufacturing environments, there may also be a need to track energy consumed per unit of production. In these cases, a retrofit energy metering system is a great option because they are designed to address requirements around ease of installation, small footprint, cost per metering point, and having a minimal impact on operations. Wireless communicating energy sensors are well suited for monitoring closer to the load on smaller circuits because they are installed directly underneath the circuit breaker and they do not require any communication wiring. As **Figure 5** illustrates, a communication gateway is used to collect power measurement data from the wireless sensors and sends it to EPMS software via an Ethernet network.

Figure 5
Wireless energy monitoring equipment



If a large number of branch circuits need to be monitored in several electrical panels in the same room, a high-density, multi-circuit retrofit metering system is a good option (see **Figure 6**). These systems use current transformers installed on circuits in electrical panels that are wired directly to a metering module that is connected to a head unit which collects the power measurement data and sends it to EPMS software via an Ethernet network.

Figure 6
High-density retrofit metering system



These metering systems are very useful if power quality monitoring is needed at a branch circuit level because some are capable of capturing high speed power quality events and associated waveforms.

Connect smart devices to EPMS software

The key enabler of power digitalization is EPMS software. It connects to devices, reads data from them, stores it in a database, and makes it available for people to use through a variety of web interfaces.

To acquire data from devices over the network, EPMS platforms primarily use Modbus because it is the industry standard communication protocol for power automation, monitoring & control devices (e.g. protection relays, circuit breakers, transfer switches and power meters), power conditioning equipment (e.g. power factor correction units, active harmonic filters, dynamic voltage restorers and UPSs), variable speed drives, and industrial monitoring & control devices (e.g. PLCs and RTUs). A typical EPMS system architecture, as shown in **Figure 7**, will have an application server installed on a physical or virtual server that is connected to the same Ethernet network as the smart devices. The application server is responsible for the data acquisition from the field devices and interaction with the EPMS database for historical data storage. It is also the core software component that makes information available to the users of the system via EPMS web clients.

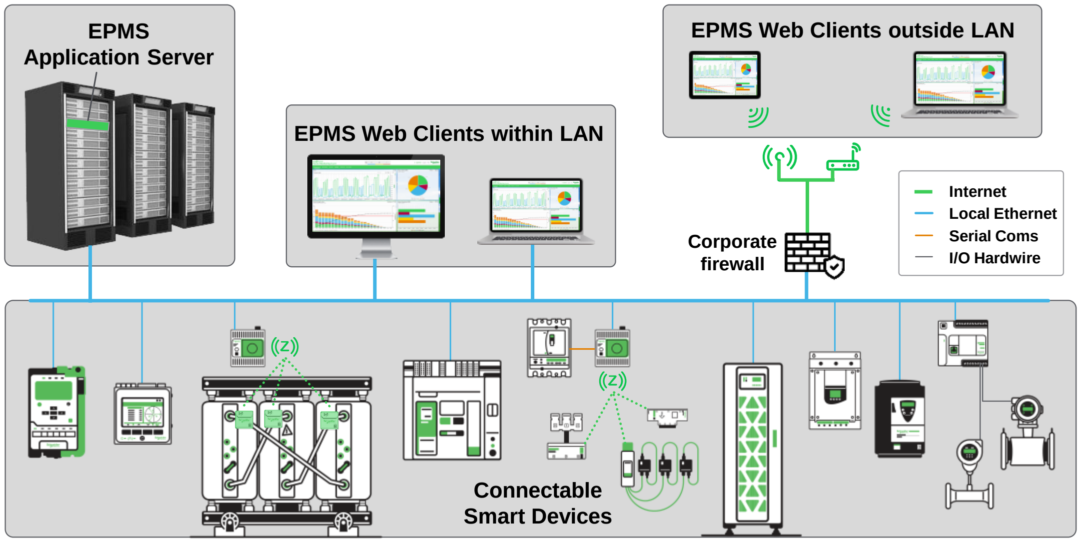


Figure 7
EPMS system architecture

A key function of the application server is to continuously check all connected devices for new alarms or new timestamped entries in their onboard data and event logs (if supported by the device). In the case of power quality meters, the application server will upload timestamped power quality event information and any associated waveforms that were captured by the power meter. For connected devices that do not store timestamped data onboard, the application server can interrogate them at regular intervals (usually every 15 minutes), timestamp the reading and store it in the EPMS database to create a structured historical dataset representing what happened over time at that metering point. The application server also requests real-time values from specific devices when an EPMS web client application is open and displaying live data.

To communicate with a variety of different device types, the application server uses components called, device drivers. These files declare which protocol formats to use and defines measurement names for the device registers that will be polled. Each type of device needs its own device driver file. EPMS software usually has built-in device type drivers and provides the ability to modify existing or create new device driver files.

Access information via EPMS web clients

People who use EPMS software, such as energy managers, facility personnel, and building operators, can access the system and view information via a web browser from virtually anywhere. An EPMS application server might use Microsoft Internet Information Server (IIS) as its web server, for example, which means secure remote client access can be accomplished using existing conventional network infrastructure and remote access technologies (e.g. Virtual Private Networks).

Whether one is accessing the web applications locally or remotely, EPMS software platforms provide a variety of ways to visualize and analyze energy usage and electrical system information, including real-time trending, alarming, graphical operational views, summary dashboard views, and preformatted reports.

It is also important to check that the EPMS is designed to be cybersecure and meets international standards for cybersecurity. It is recommended to only use an EPMS system that is certified compliant to IEC 62443-4-1:2018 as a minimum. For more information about developing a cybersecurity strategy for smart buildings, refer to white paper, *Five Attributes of an Effective Risk Management Strategy for Smart Building Cybersecurity*.

Step 2: Automate

The second step of power digitalization involves streamlining activities that were previously tedious, manual, or not done at all. The key is to use EPMS software to automate processes, simplify tasks and free up human resources to work on higher-value activities and projects. Note, there are forms of automation that occur in Step 1 (e.g. automatic data acquisition from field devices) but this section focuses on the automation of management functions.

Evaluate energy usage

Analyzing energy usage patterns helps answer some key questions posed in the "Defining power digitalization" section and is fundamental to active energy management, improving energy efficiency, and carbon reporting. As a starting point, EPMS software should be connected to devices that measure utilities (water, gas, electricity, steam) coming into a building to monitor the total energy consumption. It is also important to study how energy is consumed within the building so that opportunities to improve energy efficiency, avoid waste, and reduce carbon emissions can be identified and justified. For more information about establishing an energy management plan, please refer to white paper, *Guide to using IEC 61557-12 standard to simplify the setup of an energy management plan*. Most EPMS software platforms will come equipped with a variety of energy visualization and analysis tools such as period over period comparisons, calendar views, heat maps, Sankey diagrams, and Pareto charts, as shown in **Figure 8**.

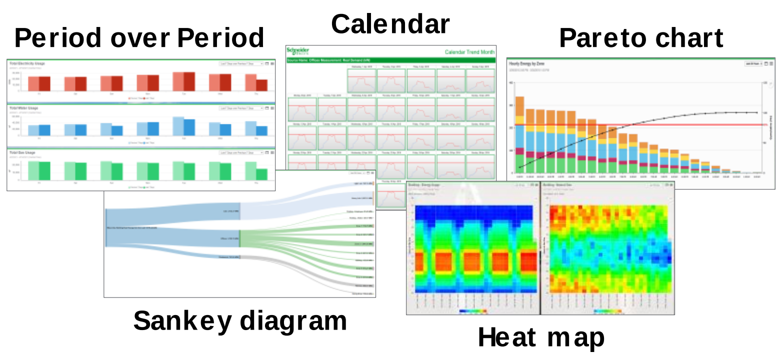


Figure 8
Variety of energy visualization and analysis tools typically provided by EPMS software

Track energy performance

Energy usage measurements by themselves are usually not an adequate indicator of energy performance. There are many factors that affect energy usage and these variables should be taken into account as much as possible. For example, outdoor air temperature and occupancy can have a significant impact on energy usage in a commercial building. In manufacturing environments, energy usage can be affected by which production lines are running and what product is being made on each line. When energy usage measurements are adjusted or "normalized" for independent variables, it becomes a new measurement known as an energy performance indicator (EnPI). According to ISO 50006:2014, energy performance improvement is the measured difference between an energy baseline (EnB) and present EnPI level.

Once appropriate EnPIs have been selected for the whole building, areas of the building or subsystems of the building, then EPMS software can be used to automate the EnPI calculations. For more advanced energy performance monitoring, EPMS software can also be used to show actual EnPI compared to expected EnPI based on an energy model. **Figure 11** provides an example of automated energy performance tracking in which the actual measured energy performance (blue line) is plotted against the expected energy performance (orange). The expected energy performance data is calculated by the EPMS software based on an energy model that takes into account things like outdoor air temperature and typical energy usage for a given day of the week.

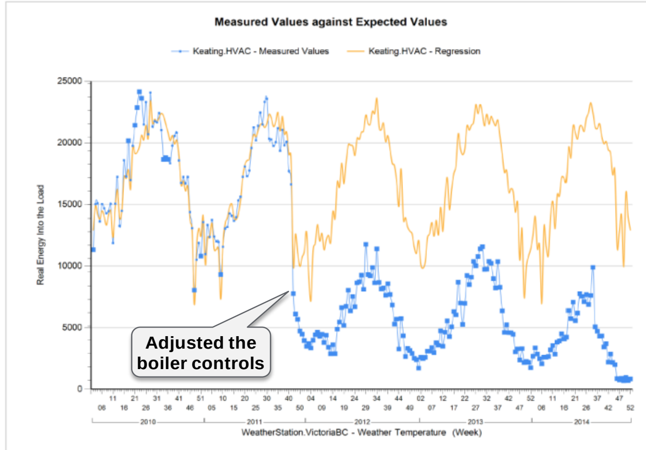


Figure 11
Using EPMS software to track improved energy performance after the boiler controls were adjusted in a building

It is recommended to select an EPMS software platform that is specifically designed to support the establishment of EnBs and track EnPIs in accordance with ISO 50006:2014 and is certified as an ISO 50001 Energy Data Management System. Companies that follow the ISO 50001 standard and use a certified Energy Data Management System to track their energy performance yield significant energy reduction savings with attractive returns on their investment.[16,17,18,19]

Manage energy costs

80% of companies are overcharged on utility expenses

National Utilities Refund

Inspecting your energy bills and understanding how your utility charges you for energy is a basic energy management activity. However, electricity is the most complex of the common utilities when it comes to rate schedules and how power companies calculate the various line items that appear on your bill. Utilities do not charge a simple, flat rate for how much electricity was consumed. They instead have several charges that relate to when and how you used the electricity. For example, there are charges that relate to the most electricity you had used in any given 15-minute window during the billing period. There are charges that relate to how efficiently the electricity was consumed during the billing period. Many tariff structures will impose a penalty if power usage within any 15-minute window exceeds a given amount or if your "power factor" ever dips below a specified threshold. For more information about ways to keep energy costs down and lower the charges on your electricity bills, refer to the article, *Top six solutions to achieve a high level of energy efficiency in buildings*.

When EPMS software is connected to metering devices monitoring the main incoming feeder(s) to a building, it can be configured to annunciate warning alarms and send notifications if a new time of use rate is about to start or if demand levels are approaching a new charge threshold or about to set a new peak demand. EPMS software can even be programmed to de-energize circuits supplying non-critical loads to prevent peak demand penalties (also known as load shedding) and it can monitor power factor and reactive power levels to help avoid power factor surcharges. EPMS software can also be used to do something called "shadow

[16] Nissan improves energy performance with SEP. Better Buildings, U.S. Department of Energy.

[17] SEP and ISO 50001 at 3M Canada's Brockville Plant. Energy Efficiency and Renewable Energy, U.S. Department of Energy.

[18] Catalyst Paper Global Energy Management Implementation Case Study. Clean Energy Ministerial.

[19] Schneider Electric Global Energy Management Implementation Case Study. Clean Energy Ministerial.

$123K is the average cost of large-account billing errors

Journal Sentinel

Thousands of utility customers wrongly charged, Aug 2010.

billing" which is the automatic generation of a line item billing report that replicates the charges on your real utility bill. This facilitates a simple visual comparison of the "shadow bill" with the utility bill to verify that the bill is correct and free from errors. This can be done for any type of utility, including water, gas, and electricity. Billing mistakes are more common than you would expect. And when billing mistakes occur, they often go unnoticed and the discrepancies can be significant. Using EPMS software to verify each utility bill and avoid surcharges and penalties saves both time and money. Catching even one billing mistake could save enough to pay for the EPMS software and the shadow billing meter. For more information about different energy management applications that are enabled by power digitalization, refer to white paper, *Guide to Energy Measurement Applications and Standards*.

Assess electrical equipment performance

In addition to facility energy management, EPMS software can be a very useful tool for diagnosing equipment problems and assessing their performance. It does this by collecting power measurement data, operational data (diagnostics and status), and configuration information (device settings) from sensors, relays, trip units, power meters, and other smart power devices that are connected to the electrical system of a building.

Sudden changes in the electrical characteristics of a circuit supplying a machine or device are often an indicator of equipment degradation or component failure. For example, checking voltage and phase imbalance can help determine if a winding is failing in a transformer, motor, or generator. If a piece of equipment starts to draw more current than it had in the past, this could be an early indicator of wear. These kinds of analyses play a big role in moving from a reactive approach to operations and maintenance to one that is much more informed and proactive.

Monitoring the power in many locations throughout a facility, especially close to the loads (equipment, machines, tools, and devices), and checking for changes to specific power parameters over time can help diagnose issues and prevent problems. Analyzing phase voltages, inrush current, phase imbalance, harmonics, neutral current, and frequency can be a useful compliment to the diagnostic information provided directly by equipment such as ATS's, UPS's, generators, inverters, and VFD's. EPMS software, as shown in **Figure 9**, can collect all this data and make it readily available for people to inspect and interpret.

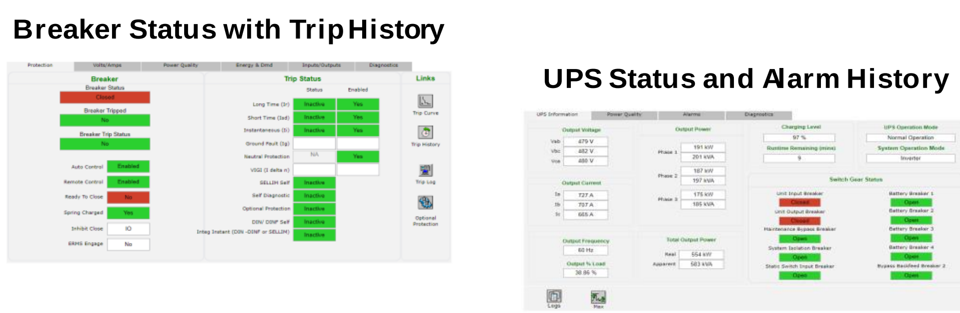


Figure 9
Using EPMS software to monitor equipment status and diagnose issues

Detect power equipment problems early

Power digitalization has changed the way transformers, generators, breakers, UPS's, and power factor correction equipment are monitored and maintained. Once connected to EPMS software, they can be monitored 24/7 based on available status outputs, internal diagnostics, electrical measurements, and environmental data. If a problem is detected, the EPMS software can sent alerts to specific people or groups of people and detailed equipment reports can be automatically generated and distributed to save time and speed up the diagnostic process (see **Figure 12**).

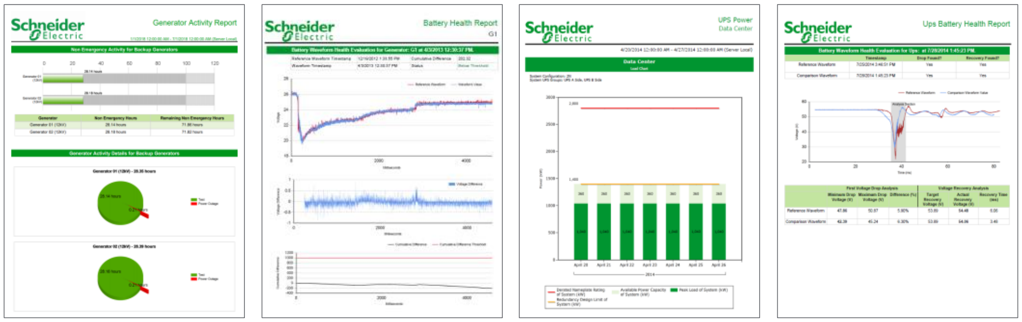


Figure 12
Examples of equipment reports automatically generated by EPMS software

Generator Activity | **Generator Battery Health** | **UPS Power** | **UPS Battery Health**

EPMS software can also be used to automatically check if any breaker settings have been changed. This may sound simplistic, but it is incredibly useful. When maintenance work is scheduled, typically the power needs to be shut off in the area and the breaker settings are temporarily changed. Sometimes, the breaker settings are not changed back after the circuit is re-energized and the breaker may not operate as desired when under load conditions. This can lead to nuisance trips or inadequate protection. EPMS software helps avoid breaker settings confusion by automatically notifying personnel any time the settings are changed.

In some cases, pre-engineered analytics can be applied to diagnostic and operational data captured by the EPMS software to determine if the equipment is in need of inspection or servicing. A great example of using analytics for predictive maintenance purposes is circuit breaker aging and wear (**Figure 13**). When ambient temperature and humidity data collected from environmental sensors is combined with operational data captured by smart circuit breakers, it is possible to predict the aging and wear of the breakers for improved safety, reliability, and lower maintenance costs. For more information, refer to white paper, *How predictive maintenance for circuit breakers optimizes safety, reliability, and costs*.

(a) (b)

Figure 13
a. Arc chute electrical wear inside a low voltage air circuit breaker

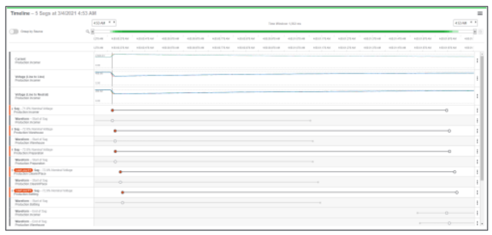
b. Worn air circuit breaker contacts

Another example is the continuous thermal monitoring of cables, busbar, and busway. When thermal and heat sensors are installed inside electrical panels and transformers, EPMS software can be used to detect rising temperatures and automatically notify personnel if a hot spot is developing. An increasing differential temperature between two phases is indicative of a hot spot which is usually caused by loose, damaged, or corroded electrical connections. To learn more about this topic, refer to white paper, *How thermal monitoring reduces risk of fire more effectively than IR thermography*.

Analyze power events

When there is a power interruption or an electrical problem, it is important to know what caused the issue so that it can be resolved safely and effectively. Having a thorough understanding of the sequence of events that led to a disruptive incident also helps decision makers take preventative actions to mitigate future occurrences. When an EPMS is connected to highly accurate, time-synched power devices (such as protection relays, breaker trip units, and advanced power meters) it can be a valuable troubleshooting tool for operators, technicians, and engineers for diagnosing power-related issues and determining the root cause. Example EPMS power event analysis user interfaces are shown below in **Figure 10**.

Timeline Analysis



Waveform Analysis

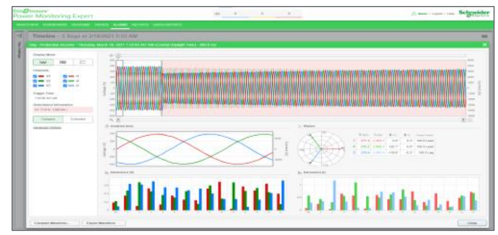


Figure 10
Analyzing power events using EPMS software

EPMS software helps users conduct detailed power event analysis by placing the sequence of events on a timeline, including alarms and waveform captures. The ability to inspect and compare waveform captures also improves analysis. For more information about the benefits of analyzing waveforms, refer to white paper, *Analytics enabled by waveform analysis*.

Streamline power quality management

Diagnosing power quality problems and determining what to do about them can be a big challenge for facility management personnel. There are several different types of power quality disturbances and they each have their own causes, potential impacts, and remedies. These kinds of problems are often misdiagnosed, leading to external specialists being hired to conduct power quality audits, diagnose specific problems, and propose solutions, but this can be very time consuming and expensive.

When power quality meters are installed and connected to EPMS software, the electrical system can be continuously monitored for all types of power quality phenomenon ranging from sudden, short-duration disturbances to chronic, persistent conditions. An EPMS can help automate several aspects of power quality management including classification of voltage disturbances, power quality performance tracking and compliance reporting.

Voltage disturbance classification
When an EPMS detects a power quality disturbance, it records it and classifies it. It is recommended to look for EPMS software that can **automatically classify short-duration voltage disturbances** according to their:

- **Type** – based on Disturbance Categories defined in IEEE 1159-2019 and Sag Types defined in IEEE 1668-2017.
- **Origin** – relative to the metering location (i.e. upstream or downstream).
- **Impact** – automatic determination how much load was lost because of the voltage disturbance. For more information about automatic load loss detection, refer to white paper, *Voltage Sag Analysis and Load Loss Detection*.

Power quality performance tracking

Companies that operate industrial and commercial facilities can benefit from monitoring the quality of electricity that enters their buildings and powers their HVAC lighting, data centers, appliances, machines and equipment. EPMS software can provide a means to track how a facility is performing over time from a power quality perspective. **Figure 14** shows a power quality performance summary dashboard.

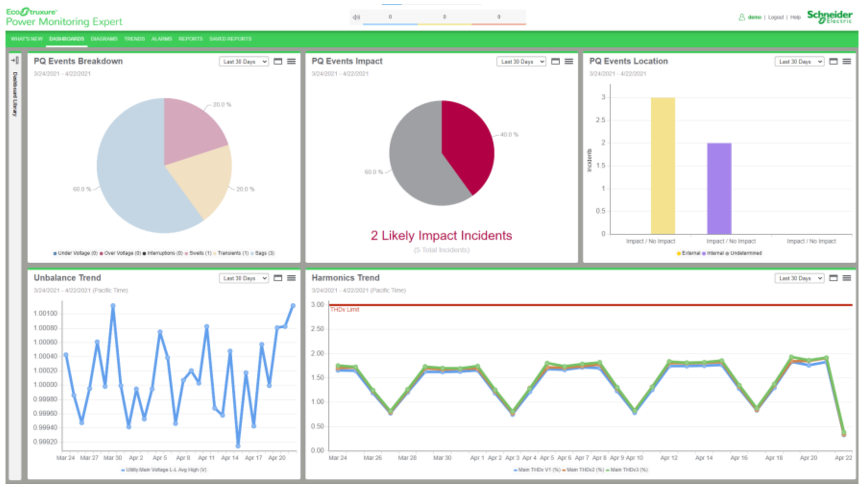


Figure 14
Example of a power quality performance dashboard in EPMS software

Power quality compliance reporting

In Europe, electricity distribution companies must supply high quality power to industrial and commercial facilities in accordance to EN50160:2010. An EPMS can be used to automatically generate and distribute EN50160 reports on a regular basis to streamline the process of checking the quality of the power being supplied by the utility. If the utility falls out of compliance, they should be contacted to discuss ways to remedy the current situation and improve it in the future. **Figure 15** shows an example of an EN50160:2010 compliance report.

EN50160v2010 Report

11/12/2019 12:00:00 AM - 12/12/2019 12:00:00 AM (Server Local)

Measurement and Observation Period Compliance Table

Complete Compliance in this Summary?		No								
EN50160.REY_PM8000_750kVA		Power Frequency	Supply Voltage Magnitude	Flicker	Supply Voltage Dips	Short And Long Interruptions	Supply Voltage Swells	Supply Voltage Unbalance	Harmonic Voltage	Interharmonic Voltage
Observation 1	12/6/2019	Yes	No	N/A	Yes	Yes	Yes	No	Yes	N/A

Figure 15
Example of an EN50160 compliance report

With the prevalence of power electronics found in all computers, digital devices, and microprocessor-controlled equipment, electrical networks are being polluted by increasing levels of harmonics. Excessive harmonics can cause significant problems ranging from equipment damage and data loss to motors overheating and nuisance breaker trips. IEEE 519-2014 is a standard that focuses on harmonic measurements and provides recommended limits for voltage and current distortion in power networks. EPMS software can be configured to send notifications to people if specific harmonic thresholds are ever exceeded and IEEE 519-2014 compliance reports can be automatically generated to facilitate the process of examining the status of harmonics in the power network. **Figure 16** shows an example of an IEEE 519-2014 compliance report.

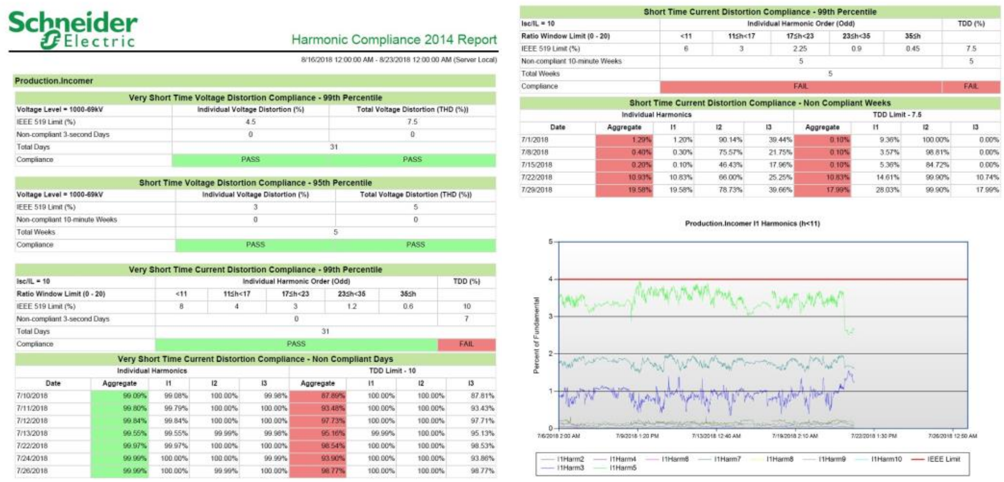


Figure 16
Example of an IEEE 519-2014 harmonics compliance

Step 3: Extend

The third step of power digitalization involves integrating the EPMS with other systems and connecting to the cloud for the purposes of sharing information, making EPMS applications more accessible and enabling a variety of digital services. We also discuss the benefits of partnering with external expert service providers to get the most out of your power digitalization investment.

Exchange data with other management systems

Most software system integration involves sharing data from one system to another. For example, if energy usage data is collected by a building management system, or a process SCADA system, an EPMS can be configured to acquire the data from those systems rather than polling the individual field devices over the network. Conversely, an EPMS can also share its data with other systems. Since EPMS software is specifically designed to acquire power and energy data from a variety of device types throughout a facility, it is recommended to use the EPMS as a central power & energy data collection engine and let other systems retrieve the data they need from it. Systems that are typically connected to an EPMS for data retrieval include enterprise energy management, billing, accounting, ERP and integrated workplace management systems.

In addition to sharing energy data, passing alarm information from one monitoring and control system to another can be incredibly valuable. For example, when an EPMS detects a problem in the electrical system, the alarm can be sent to a building management or process SCADA system so operators are made aware of the issue in the software interfaces they normally use. **Figure 17** illustrates these potential software integrations.

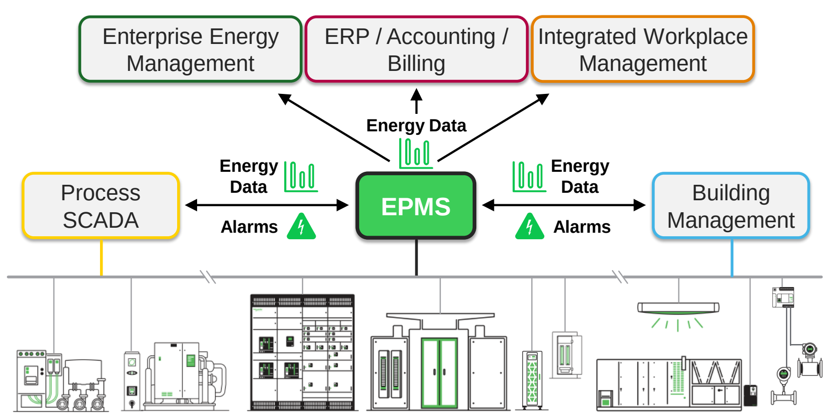


Figure 17
Overview of EPMS data integrations with other management systems

Embed EPMS applications within other systems

In addition to exchanging data among systems, EPMS applications can also be embedded in the web client environments of other supervisory systems (**Figure 18**).

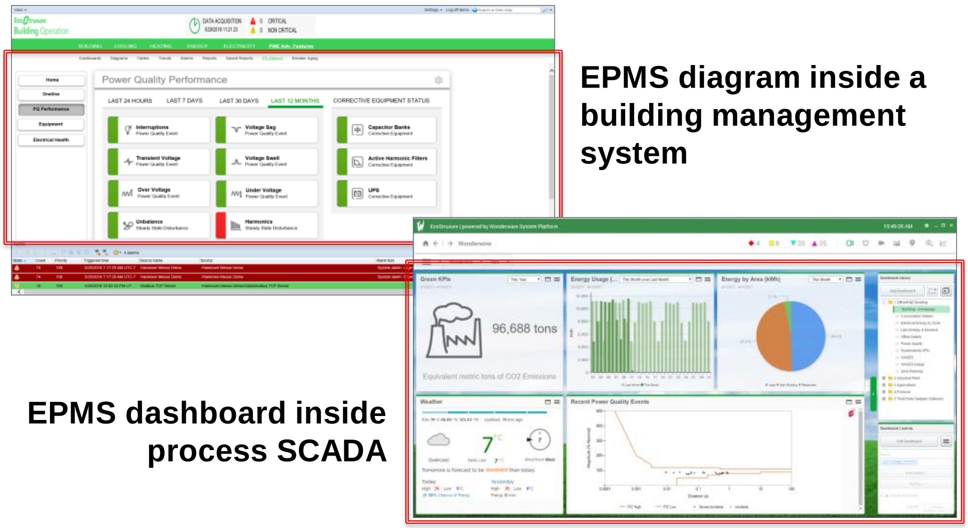


Figure 18
Examples of embedding EPMS applications in the web client environments of other supervisory systems

Integrating different management systems together can yield many benefits, including greater overall visibility of operations, better understanding energy usage in the context of operations, more efficient troubleshooting, more comprehensive alarm management and enhanced ability to analyze data and automate processes. To learn more about the benefits of integrating an EPMS into a building management environment, refer to white paper, *The Impact of Power Management on Building Performance and Energy Costs*. For more information about the benefits of having an EPMS embedded in an industrial manufacturing environment, refer to white paper, *How can you improve operational performance by tracking and analyzing energy data?*

Connect to Cloud

Even though traditional EPMS architectures are proven to work. There is no question that a cloud-based approach is challenging the on-premise paradigm and offers some very compelling reasons to move EPMS functions to the cloud. The benefits of moving EPMS capabilities to cloud and offering them as software as a service (SaaS) include:

- **Cost effective** – no local IT infrastructure costs or EPMS software installation and maintenance costs
- **Automatic updates** – EPMS software features and updates provided
- **High availability** – reputable cloud providers (such as Microsoft Azure) have proven track records for up-time and service continuity
- **Cybersecure** –widely accepted that cloud-based applications are more secure than on-premise
- **Advanced analytics** – descriptive, predictive and prescriptive analytics provide deep insights for enhanced decision support and recommendations
- **A la carte functionality** – EPMS modules can be added or removed quickly

For more information about the benefits of moving EPMS applications to the cloud and which functions should remain on-premise, refer to white paper, *Do more with less: Moving power and building management to the cloud*.

Partner with expert service providers

Organizations that understand the benefits of power digitalization may still be reluctant to implement an EPMS due to a lack of local resources and expertise to operate and maintain it. Companies that once had personnel trained in power distribution systems may find themselves without any electrical system domain knowledge. Facility management teams that operate commercial properties may have a strong background in HVAC and building control systems, but may not be experienced in troubleshooting electrical issues and conducting energy management activities. When experienced resources with specialized skills are in short supply, partnering with an EPMS system integrator can be a very good way to get the guidance and expertise that is needed. Companies that engage external services have experienced a positive impact towards achieving their goals, especially in the areas of operational efficiency and resiliency.[20]

Power digitalization, cloud connectivity, and remote access technologies are allowing service experts to provide monitoring, analysis, and decision support in ways that were not possible in the past. And many system integration companies that once focused primarily on engineering, deploying, and supporting EPMS systems are expanding their offering to include services that are more outcome-oriented and consultative. Examples of such services include:

- **Power quality audits** and **mitigation planning** – provide specific recommendations for how to improve power quality
- **Energy audits** and **management planning** – evaluate existing systems and operations for energy efficiency and help develop an energy conservation plan
- **Remote troubleshooting** – diagnose power issues and equipment problems
- **Remote monitoring** – check power system performance and energy usage
- **Data integrity verification** – confirm the quality of the energy data collected
- **Continuous commissioning** – collaborate on ways to improve operations, avoid downtime and optimize energy use
- **Operational technology (OT) security** – audit EPMS and associated OT environment for vulnerabilities, make recommendations to improve cybersecurity and apply patch management

[20] Jennifer Cooke, Jed Scaramella, Mukesh Dialani. *Maximizing Business and Operational Resilience Through Services*. IDC White Paper. April 2020

Conclusion

Public, commercial, and industrial buildings represent an enormous untapped potential for decarbonization. Looking forward, we believe electricity will be the most influential and important form of energy. This means buildings will need to have fully digitalized electrical distribution systems that are connected to software and the cloud, if they are to produce, store, consume, and share electricity in a sustainable and resilient manner. This all starts with a concept known as **power digitalization**.

Power digitalization is a key enabler of active energy management, efficient facility operations, and carbon tracking. It is accomplished by retrofitting electrical systems with smart devices and connecting them to software to establish an energy and power management system (EPMS). An EPMS enables power system and energy usage analysis and facilitates the automation of many manual, tedious, and error prone tasks. This ultimately helps facility management and maintenance personnel make better decisions, resolve issues more quickly, minimize downtime, and use less energy.

Power digitalization transforms organizations from being uninformed and reactive to those that are insightful and proactive. An investment in power digitalization ensures that building owners and investors get real-time carbon tracking and transparency about their building's energy usage and it is essential in avoiding obsolescence.

About the author

Tony Hunt, MSc, CEM, CPQ, works for Schneider Electric as a global marketing manager specializing in bringing energy and power management applications to end user markets such as data centers, healthcare, industry, infrastructure, and commercial and public buildings. As a Certified Energy Manager and a Certified Power Quality Professional with over twenty years of experience in the fields of energy management and power quality, Tony remains an instrumental contributor to Schneider Electric's vision of a sustainable and productive future in the New Electric World.

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