May 2023

Electricity metering for a sustainable future

Life Is On | Schneider Electric

Explore Sustainability

Contents

Foreword

We have been living in an age of fire. Since harnessing its power, it has fueled massive industrialization, population growth and prosperity. But it has come at a cost. The burning of fossil fuels such as coal, natural gas, and oil has added significant amounts of carbon dioxide and other greenhouse gases to the atmosphere which has caused our planet to heat up to dangerous levels.

At COP 21 in Paris, the United Nations Framework Convention on Climate Change (UNFCCC) reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future. In 2016, the "Paris Agreement" was signed and went into action with a central aim to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5°C.

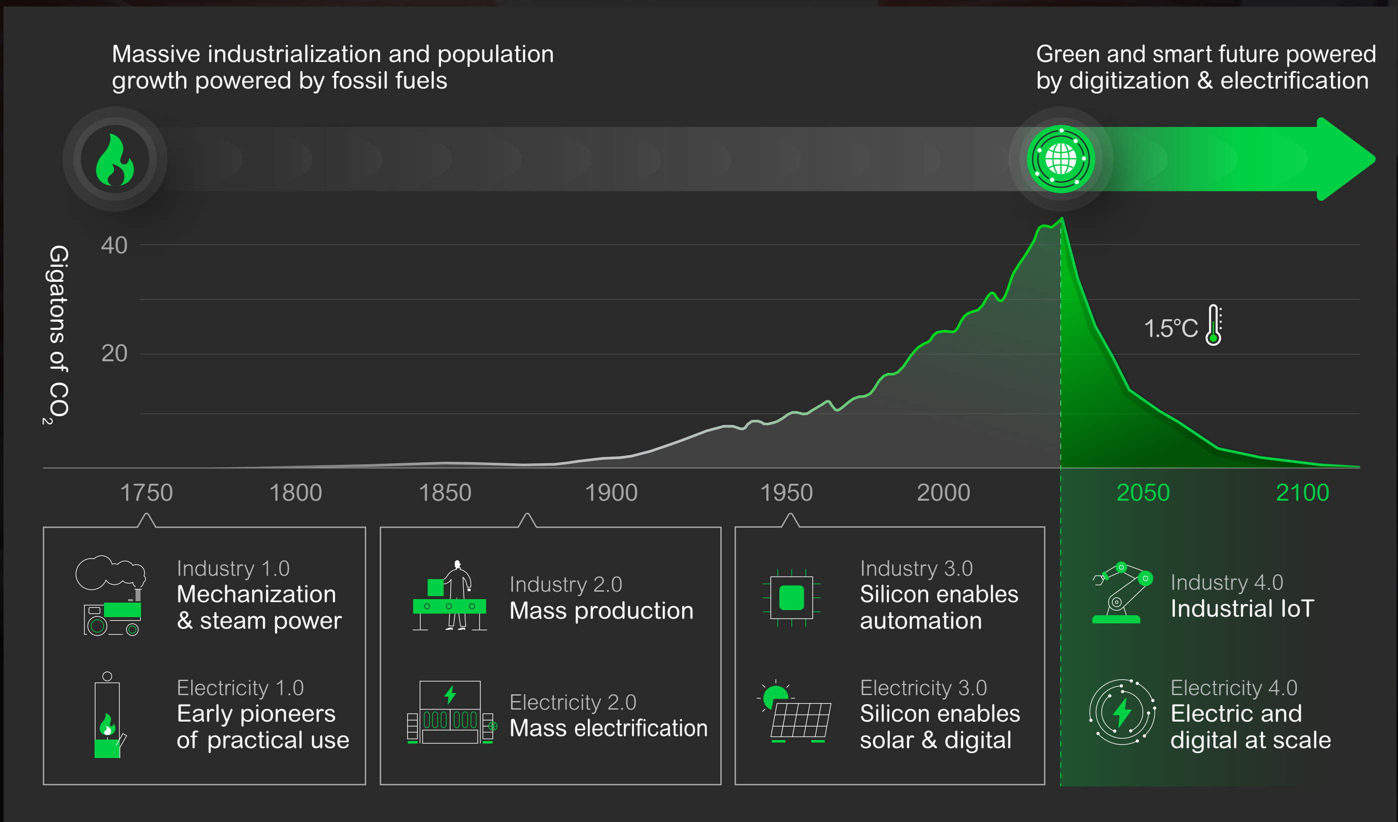
50%

Final energy use is electricity by 2050 - up from 20% today

IEA Reports
World Energy Outlook, 2021

Electricity 4.0: The fastest path to Net Zero

Today, we are at a critical juncture. It is not our actions over the course of this century that will define our impact, it is our actions over the next decade. If we are to reach the 1.5°C target, CO_2 emissions must be halved by 2030. It is this short window that will determine our pathway to carbon neutrality by 2050.



As we shift from fossil fuels, the world is turning to electricity because it is a cleaner, more efficient form of energy (3-5 times more efficient than other sources) and the best vector for decarbonization. It is becoming clear that our future will need to be more electric and more digital if we are to meet the 1.5ºC and be net zero by 2050.

Over the last 250 years, the world has gone through four technology-driven "industrial" revolutions with the most recent being termed Industry 4.0 in which networks of smart machines are able to create and share information to ultimately make decisions without human involvement.[1] Similar to the industrial revolutions, electricity has also gone through several revolutions from the first industrial uses of electricity to mass deployment, to the birth of green power and decentralization. Today, we are entering the fourth wave of innovation and advancement known as Electricity 4.0 in which cyber-physical systems, the Internet of Things, and the Internet of Systems are combining to bring more intelligent power automation, self-monitoring power grids, and electrical distribution systems.

For more information about Schneider Electric's approach to limiting global warming to 1.5ºC by 2050, visit our website and read our report called Back to 2050.

30%

of global energy consumption comes from buildings and building construction sectors

IEA Topics
Buildings

The new energy landscape

The buildings and buildings construction sectors combined are responsible for 30% of total global final energy consumption and 27% of total energy sector emissions. And 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.[2]

To achieve net-zero buildings, significant efforts to decarbonize through the use of renewable energy, process electrification and energy use optimization technologies will need to be undertaken for all buildings: new and existing. Buildings of the future will have onsite renewable power generation (e.g. solar, wind, geothermal, fuel cell), energy storage (e.g. battery energy storage systems, flywheels), electrical HVAC systems (e.g. heat pumps), EV charging stations and interactive connections with the power grid. In order to support these kinds of flexible energy systems, buildings will need to have fully digitalized electrical infrastructure to provide the data required to operate and maintain these more complex electrical systems in the new energy landscape.

This eBook presents information about electricity metering and the digital applications that depend on power measurement and energy usage data generated by electrical metering devices, followed by descriptions of the key metering locations in modern buildings with complex electrical systems with guidance for consultants and engineers who need to specify and design electrical metering systems for new or existing buildings.

[1] Bernard Marr, "What is Industry 4.0? Here's A Super Easy Explanation For Anyone" Sept 2, 2018.
[2] Buildings - A source of enormous untapped efficiency potential from International Energy Agency (IEA)

The need for electricity metering

Historically, the demand for 3-phase power meters has been driven primarily by electrical distribution system designs and specifications for power monitoring and energy management software systems.

Electrical distribution system designs for facilities such as hospitals, data centers, and manufacturing plants usually specify power meters in key locations in the electrical network, such as in the main switchboards, primary distribution feeders, backup power distribution panels, secondary distribution panels and on the incomers of smaller electrical panels closer to the loads. Advanced power quality meters may be specified for monitoring main incomers and primary distribution circuits, whereas a more basic power meter may be specified for monitoring secondary distribution and smaller circuits. It is common to also have requirements for electrical power management system (EPMS) software. The purpose of an EPMS is to help operators, maintenance and facility management personnel understand how the electrical distribution system is performing, manage power sources and loads, isolate parts of the network, diagnose electrical problems and restore power quickly and safely after maintenance or service disruptions.

Most electrical distribution designs for commercial, institutional and public buildings also specify power meters, but the requirements are typically quite basic with the primary goal of capturing energy usage data for energy management rather than real-time power measurement data for electrical system performance monitoring. Multi-tenant building projects will normally have special requirements for metering locations that are used for tenant billing and occasionally a tenant billing system is prescribed in conjunction with the tenant billing meters. Rarely is an EPMS specified in these situations, but energy monitoring/management systems (EMS) or energy information systems (EIS) are commonly prescribed so energy managers and facility managers can analyze energy usage and track their energy performance.

Power meter requirements can also appear in building management system (BMS) and process automation/control system specifications. In these cases, power meters are typically prescribed for monitoring the energy consumption of building loads (HVAC equipment, elevators, escalators, refrigeration equipment, large appliances, lighting) or process loads (heating, cooling, ventilation, pumps, motors, fans, compressors, arc welders, specialized equipment) and the requirements are usually very basic and focused on collecting kWh energy usage readings.

Even though power meters are regularly specified in electrical, mechanical, and process automation system designs, value-engineering and project cost pressures often result in fewer meters being installed. The added cost of installing and connecting smart power meters throughout a facility has always been a challenge to justify for both new construction and renovation/expansion/modernization projects. Unless there were specific requirements for power quality monitoring or tenant billing, it was unlikely that an ROI could be proven for additional metering points. Despite the well-documented benefits of measuring energy consumption as part of an energy management system for continuous improvement and cost savings,[3,4,5,6,7] the appetite for investing in electrical submetering has only slightly improved over the last two decades. The payback has not been simple enough to explain and as a result, submetering has remained a “luxury item” or a “nice to have”.

But this has changed. Today, more than 70 countries have set a net-zero carbon target, covering about 89% of global emissions. Over 1,200 companies have put in place science-based targets in line with net zero, and more than 1000 cities, over 1000 educational institutions, and over 400 financial institutions have joined the Race to Zero, pledging to take rigorous, immediate action to halve global emissions by 2030.[8,9] The pressure to decarbonize is changing the energy landscape and driving the need for comprehensive electricity metering in facilities and buildings due to a combination of factors:

- Building energy codes and regulations
- On-site renewable energy generation and storage
- Process electrification and EV charging stations
- Price of electricity
- Degradation of power quality

The primary reason digital electrical metering devices are installed in buildings is to collect power measurement and energy usage data and share it with other devices, software systems and remote applications via communications.

[3] Zhiqiang (John) Zhai, Andrea Salazar. Assessing the implications of submetering with energy analytics to building energy savings, Energy and Built Environment, Vol 1, Issue 1, January 2020

[4] Making Permanent Savings through Active Energy Management – Schneider Electric white paper

[5] The Impact of Power Management on Building Performance and Energy Costs – Schneider Electric white paper

[6] Implementing an energy management system - Your guide to ISO 50001 compliance – Schneider Electric white paper

[7] Craig B. Smith, Kelly E. Parmenter. **Energy Management Principles: Applications, Benefits, Savings** – Nov 6, 2015

[8] Net-zero commitments must be backed by credible action - UN Net-zero coalition

[9] Taking stock of progress - September 2022 Report - Race to Zero and Race to Resilience

Building energy codes and regulations

Building energy codes and regulations are emerging throughout the world that require buildings to have systems in place to monitor and report energy use throughout the facility. Countries are implementing and updating standards, policies, programs, and regulations related to energy efficiency and building energy performance. The EU's Energy Efficiency Directive (EED) and Energy Performance of Buildings Directive (EPBD) are great examples of this. Even though building codes, standards, and energy regulations vary in their scope and complexity, they all have one thing in common: a requirement to measure energy usage on a continuous basis and track electricity consumption by load category. These core requirements along with the need for companies to become net zero are driving the need for implementing cost-effective electrical submetering systems for both new construction scenarios as well as for building modernization retrofits. Having a system in place that continuously measures energy usage throughout a building and reports electricity consumption by load category is no longer optional – it is becoming mandatory in most places.

The main types of building energy codes in use around the world are:

- **Prescriptive codes** - Set performance requirements for specific building components.
- **Performance-based codes** - Set a maximum level of energy consumption or intensity for the whole building.
- **Outcome-based codes** - Require specified outcomes to be achieved & verified over a period of at least 12 months.

In addition to energy codes, standards and regulations, there are also many different organizations that offer "Green Building" programs that provide information, guidelines, benchmarks, and recognition based on how energy efficient and/or sustainable a building is. Program adoption varies in different parts of the world. Some programs operate at an international level whereas others may be popular in select geographies and some only exist within a single country. But regardless of their adoption and specific scope, they all have the common goal of improving the energy efficiency of buildings to reduce our carbon footprint.

For more information about building energy codes, standards & regulations and how to design an electrical system to help maximize energy efficiency and building performance, read our whitepaper Designing electrical systems for future-proof, energy-efficient green buildings.

For more information about green building programs and rating systems, read our paper called Green Buildings Certifications.

On-site renewable energy generation and storage

Solar photovoltaic is the cheapest source of energy today and by 2030, about 40% of all electricity used in buildings could be supplied by solar and wind.[10] The addition of on-site renewable energy generation and storage in buildings introduces new locations and requirements for electricity metering. From an energy management and carbon reporting standpoint, measuring the amount of locally generated energy is straight forward, however from a power reliability perspective, the integration of variable renewable power generation and DC power systems with the main AC electrical distribution systems of buildings is giving rise to more advanced metering requirements related to power quality monitoring. As the electrical distribution systems of buildings get more complex and dynamic, the need for power quality monitoring will also continue to grow.

Process electrification and EV charging stations

The heating of most buildings around the world still relies on fossil fuels, particularly natural gas. Heat pumps are a hyper-efficient and climate-friendly solution that provide space heating and cooling more efficiently than most existing fossil fuel burning systems. To be on track for net zero globally by 2050, 14 million heat pumps need to be installed in buildings each month. The electrification of buildings also includes substituting gas burning appliances such as boilers, furnaces, water heaters, stoves, ovens and dryers with their electric equivalents.

Electrification is happening in the parking lots of buildings as well. In fact, building codes in some regions of the world are requiring dedicated electrical capacity for EV charging stations for all new builds.

To accommodate this massive transition to electrical heat pumps, electric appliances and EV charging stations, buildings will need larger electrical systems and more metering in place to monitor the additional electrical loads and to be able to measure energy usage down to the load level.

40%

of all electricity used in buildings could be supplied by solar and wind by 2030.

IEA Reports
Technology and innovation pathways for zero-carbon-ready buildings by 2030

500
Mt CO_2

Global reduction in emissions with heat pumps instead of gas burning heating/cooling equipment.

IEA Reports
The Future of Heat Pumps

[10] Solar PV and wind supply about 40% of building electricity use by 2030, IEA Technology Report, September 2022.

Price of electricity

The pressure to improve energy efficiency and reduce energy waste has never been greater. Not just because it helps lower carbon emissions but also due to the fact that energy prices continue to rise, which increases operating costs. In a highly competitive world where margins are thin, optimizing energy use can have a direct and positive impact on profitability.

Of all the forms of energy, electricity is the most efficient to produce, distribute, and consume. But the infrastructure required to deliver it safely and reliably is complex and getting more complicated every day. In fact, this is a contributing factor to the rising price of electricity. And this complexity is directly reflected in how consumers are charged for electrical power. Electricity bills can be very intricate and difficult to understand. But hidden in those line items are opportunities to save and lower those bills. The key is to understand the rules applied to each charge and determine if changing how and when electricity is consumed will significantly reduce those charges. In many cases, there are simple ways to lower certain charges, such as demand charges, peak demand charges, on-peak usage charges or power factor charges.

Degradation of power quality

The world's power grids are rapidly changing as distributed energy resources (DERs) are being built and integrated into existing utility networks at unprecedented rates. This is needed to address the demand for green power and reduce greenhouse gas (GHG) emissions, but it also introduces a new set of challenges for utility companies who must manage a more complex power network with distributed intermittent power sources. One consequence is the more frequent occurrence of power disturbances and service interruptions. Power quality events such as these adversely the performance of equipment and lead to unplanned downtime.

The electrical distribution systems within buildings are also getting more complex and the loads they serve are smaller and more numerous. The digital and dynamic nature of the devices and equipment being installed in modern buildings is resulting in higher levels of voltage distortion and imbalance. Every switch-mode power supply and device containing power electronics (inverters, controllers, computers) will adversely affect the quality of power in the AC network. Left unmitigated, poor power quality can lead to a variety of problems ranging from device malfunction to overheating, equipment damage and failures.

Lack of clean, reliable grid power and the degradation of power quality within buildings is driving a strong demand for power quality monitoring devices as well as active correction equipment such as electronic VAR compensators, dynamic voltage restorers and harmonic filters.

15.8%

Increase in electricity price from 2021 to 2022

Bloomberg Article

US Power Prices Rise Most in 41 Years as Inflation Endures

51%

Commercial / industrial companies believe their business is becoming more dependent on clean, stable, reliable power

S&C Electric Company
in collaboration with Frost & Sullivan

2020 State of Commercial & Industrial Power Reliability Report

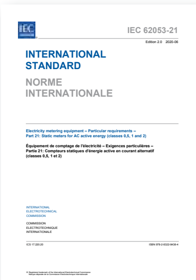
IEC standards for electricity metering

International standards play a very important role across all industries in providing guidance for international terminologies, safety and health protection, measurement, analysis, quality control, and environmental protection. For electricity metering, this is led by the International Electrotechnical Commission (IEC) and is covered by two technical committees: TC13 and TC85.

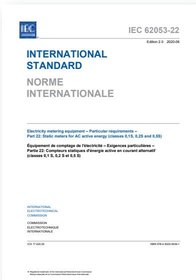
IEC Technical Committee 13: Electrical energy measurement and control

IEC TC13 covers all metering equipment across the full range of applications. They address the most important aspects of metering, provide fundamental guidance, and act as a technical reference for specification, acceptance testing, and approvals. They are used by electric utilities, metering service providers, regulators, metrology agencies, manufacturers, and electrical engineering & consulting companies. In June 2020, TC13 published updated versions of several publications, including:

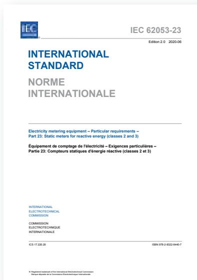
IEC 62052-11
Metering equipment



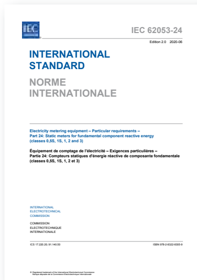
IEC 62053-21
Static meters for AC active energy



IEC 62053-22
Static meters for AC active energy



IEC 62053-23
Static meters for reactive energy



IEC 62053-24
Static meters for fundamental component reactive energy

For more information about these updated IEC Standards, refer to our whitepaper called Electricity metering for modern electrical grids.

IEC Technical Committee 85: Measuring equipment for electrical and electromagnetic quantities

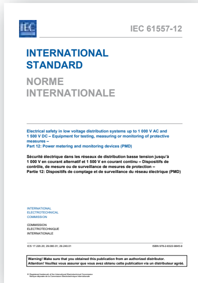
The scope of TC85 is to prepare international standards for equipment, systems, and methods used in the fields of measurement, test, recurrent test, monitoring, evaluation, generation, and analysis of steady state and dynamic (including temporary and transients) electrical and electromagnetic quantities, as well as their calibrators.

Such equipment includes devices for testing the safety of power distribution systems and connected equipment, devices for monitoring the power distribution systems, electrical measuring transducers, signal generators, recorders and their accessories.

IEC 61557-12: Power Metering and monitoring devices (PMD) is a particularly interesting standard in that it was developed to help specifiers select the right device for common electricity metering applications. It lists all possible electrical characteristics the devices might measure, along with related requirements – such as rated ranges of operation or allowable measurement techniques. The listed characteristics include:

- Active energy (with performance classes equivalent to the classes defined in IEC 62053-21 and IEC 62053-22)
- Reactive energy (with performance classes equivalent to the classes defined in IEC 62053-23)
- Apparent energy
- Active, reactive, and apparent power
- Frequency
- Root-mean squared (RMS) phase and neutral current
- RMS voltage
- Power factor
- Voltage dip and swell
- Voltage interruption
- Voltage unbalance
- Harmonic voltage and distortion
- Harmonic current and distortion
- Maximum, minimum, peak, average, and demand values

Unlike similar standards like IEC 62053-2x and EN 50470, IEC 61557-12 is a valuable standard because it defines electricity measurement performance classes which allows manufacturers to declare a PMD metering performance level with a known level of accuracy for not only active and reactive energy, but also a variety of other power and energy measurements. For more information about IEC 61557-12 and PMD performance classes, please refer to our Schneider Electric whitepaper called Guide to using IEC 61557-12 standard to simplify the setup of an energy management plan.


IEC 61557-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

IEC 61557-12 amendment 1: 2021

introduced the concept of "*Equipment embedding Power Metering and Monitoring Functions*" (EPMFs) so devices such as protection relays and circuit breakers can also measure electricity and provide power measurements to a stated metering performance class along with dedicated "Power Metering and Monitoring Devices" (PMDs).

Types of digital electricity metering devices

When specifying and designing electrical monitoring systems, it is very important to ensure that the right power measurement data is being collected for the required or intended applications. There are many considerations when specifying or selecting a power metering device for a given location in the electrical network and so it is beneficial to understand the options and know the differences among the various types of power metering devices available in the market today.

Smart devices that can measure electricity and provide of power measurement data via communications can be classified into two main categories:

- Dedicated
- Ancillary

Dedicated metering

This category contains power metering devices that are designed and manufactured for the primary purpose of measuring electricity and providing accurate power measurement data. They are conventionally referred to as "power meters". This category of power metering devices typically adheres to a variety of electricity metering standards and is what most electricity metering specifications are based on.

Dedicated power meters vary widely in their capabilities and form factors. There are dedicated power meters for monitoring 3-phase circuits, individual single-phase circuits and multiple circuits. Some have an integrated display screen and are designed to be flush mounted in the front panel of an electrical cubicle or metering enclosure. Some power meters are designed to support a remote display while others do not have any form of local display screen. Smaller, conventional power meters tend to have a DIN rail mounting option, while some wireless, direct measurement meters are small enough to simply hang on the cables next to the circuit breaker.

Most 3-phase power meters require external current transformers (CTs) but some power meters can measure current directly (up to about 160 amps max) without needing external CT's. Some 3-phase power meters come with integrated CTs. There are several types of measurement class CTs including solid-core, split-core, rope-style (Rogowski coils) and low voltage CTs (LVCTs). For installations above 600V, power meters also require external voltage/potential transformers (VT/PTs).

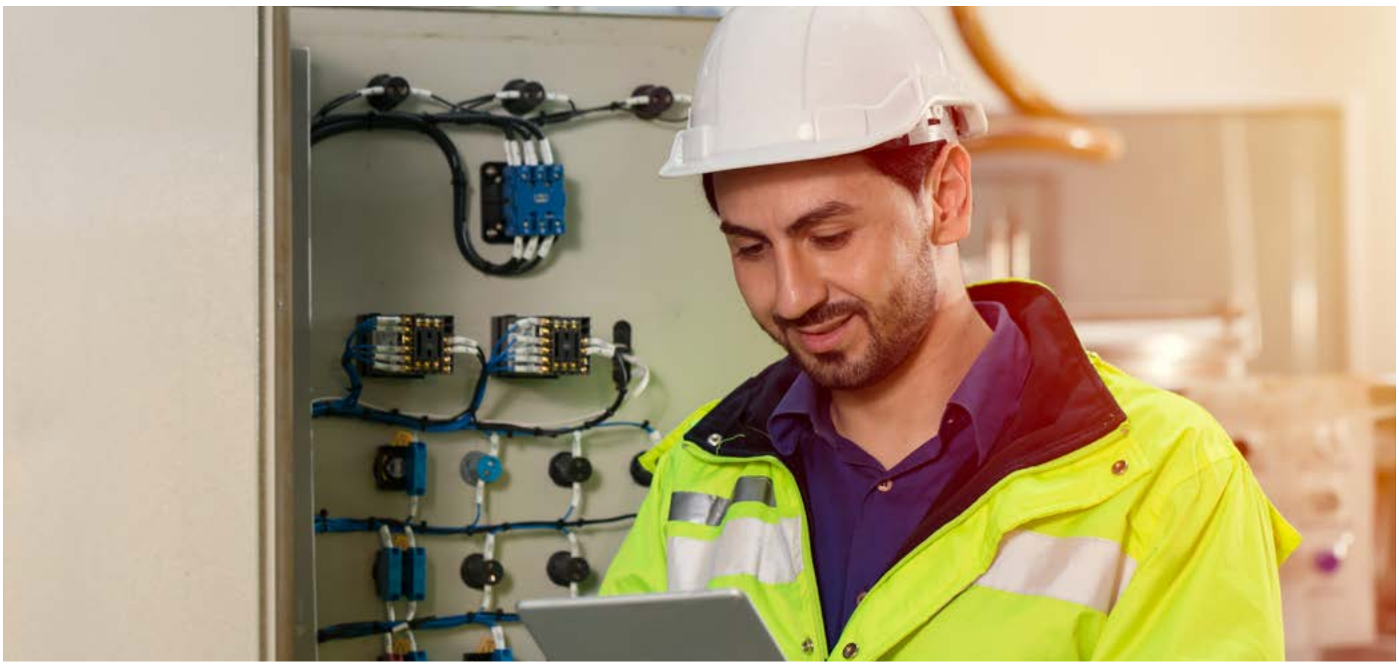
Most individual single-phase power meters support direct measurement and do not require CT's whereas most multi-circuit meter designs are comprised of a metering head unit connected to CT strips or collections of split-core/solid-core CTs.

Single-Phase meters

Circuit breaker integrated

DIN mount

Multi-Circuit meters



Ancillary metering

Ancillary metering is categorized by devices that measure electricity as a supporting function of the device but whose primary purpose is something other than power measurement, such as protection, switching, conversion or correction. Examples of such devices include relays, circuit breakers, transfer switches, power inverters, uninterruptible power supplies, drives and motor control devices. Since these kinds of devices vary widely in their form and function, the measurement techniques and accuracy of the power measurements they provide also vary.

Devices that comply to the IEC 61557-12 standard will provide power measurement data to a stated performance class (e.g. Class 1), however most ancillary metering devices do not comply to any international power metering standards and so the measurement data they provide will have an uncertain level of accuracy. For this reason, power and energy data collected from ancillary metering devices should not be used for cost allocation or billing purposes unless they comply to a recognized standard with a stated accuracy class.

Data acquisition and the role of software

Investing in a comprehensive electricity metering infrastructure to capture data throughout a building is a core pre-requisite for active energy management, carbon reporting, and efficient & reliable building operations. Power measurement and energy usage data generated by electrical metering devices can be acquired and used by a variety of software systems for a multitude of different applications serving many different people within an organization.

Some software can acquire energy data directly from metering devices over a local communications network, whereas some cannot. When designing a metering system and specifying meter communication options, it is valuable to know what type of software systems and how many software systems will communicating directly with the meters to acquire data from them.

Most on-premise supervisory management systems are based on conventional "Client–Server" communication architectures in which the software acts as the Client requesting information from the devices installed in the same communications network. The devices act as servers and only provide data when requested from the client software.

The convergence of operational technology (OT) and information technology (IT) has led to the development of metering system architectures that leverage WiFi and cellular networks to get metering data to cloud-based software platforms. Metering data can be sent directly to the cloud or acquired by on-premise data concentrator devices before being sent to the cloud. Many on-premise supervisory software platforms can also send their metering data to the cloud.

Examples of supervisory management software that can acquire data directly from metering devices include:

- Electrical power management system (EPMS) software
- Energy management system (EMS) software
- Building management system (BMS) software
- Process SCADA software
- Tenant billing software

EPMS software

This category ranges from basic power monitoring software to fully redundant, high-performant, power monitoring & control software. As a result, different system names exist depending on the region, segment and whether the software can perform control operations remotely via communications:

- Electrical power management system (EPMS)
- Electrical power monitoring (EPMS)
- Power monitoring & control system (PMCS)
- Power monitoring system (PMS)
- Power management system (PMS)

EPMS software is intended to help engineering, facilities, operations, and maintenance personnel minimize downtime, maximize power availability, and optimize power system performance. Historically, it was primarily used to monitor phase voltages and currents, manage electrical capacity, and diagnose electrical problems. EPMS software also provides valuable insights into how equipment is performing and can be used for electrical asset condition monitoring. Advancements in digital controls and communications have also introduced the ability for EPMS software to open and close circuit breakers remotely for managing power sources, controlling loads, isolating parts of the network and restoring power.

EPMS software is designed to provide real-time updates (values and alarms) from a large number of smart devices installed in the electrical network as well as acquire timestamped trend, event and waveform data from the onboard data logs of more advanced power devices (smart relays, circuit breakers, power meters). EPMS software has a graphical application for viewing electrical single-line diagrams, elevation drawings and equipment status and provides an interface for alarm/incident management. Most EPMS software will also have applications for power events analysis, load profile reporting and utility bill verification. Most EPMS software is on-premise, but cloud-hosted EPMS monitoring solutions are becoming more common.

EMS software

This category of software is very broad and a variety of system names exist including:

- Energy monitoring system (EMS)
- Energy management system (EMS)
- Energy information system (EIS)
- Building energy management system (BEMS)

An EMS can be an on-premise, client-server software system or it can be a cloud-based application. The fundamental purpose of EMS software is to create a high-quality, hierarchy-oriented, interval-energy dataset for energy use analysis and energy performance tracking. EMS software is designed to acquire energy usage data from a variety of sources including water, gas, steam, heat and electricity meters and process it into interval measurements with standard energy units.

EMS software provides a variety of energy usage visualization, analysis and reporting interfaces for sustainability officers, energy managers, and anyone who needs to track energy usage, calculate energy KPIs and share energy usage information. Some EMS systems support smart alarming to proactively notify personnel when unexpected consumption occurs. This is extremely useful for reducing energy waste and optimizing operational energy use.

EMS systems are regularly used to attain ISO 50001 site certification, gain points/credits towards a green building program and demonstrate compliance to building energy codes and regulations. EMS software can also be used for energy cost management applications such as energy cost allocation and tenant billing. More advanced EMS platforms provide tools for energy modelling and can track and quantify expected energy use against actual energy use.

EMS software is often utilized for site-level energy data acquisition. Although many EMS platforms can scale to monitor and report across multiple sites, EMS software is typically installed per site where it can share its data with other local systems, as well as with a variety enterprise platforms.

Process SCADA software

Supervisory control and data acquisition (SCADA) is an on-premise system comprised of software and hardware elements that gather, process and display real-time data for monitoring and controlling equipment that deals with critical and time-sensitive materials or events. SCADA systems are widely used in industrial environments for process automation. They help operators and other employees oversee and control operations in real-time.

Process SCADA software is designed to collect many types of data from a wide range of devices. Data is primarily in the form of real-time values and status points acquired via programmable logic controllers (PLCs) and remote terminal units (RTUs) but process SCADA software is very capable of acquiring real-time data from almost any type of smart, communicating device, including power metering devices.

Process SCADA software can display real-time electrical values and status/alarm points in operational monitoring screens, but it lacks the ability to acquire timestamped power quality events and waveform data from power meters for power quality analysis. Even though process SCADA software is extremely versatile, it is not specifically designed for monitoring and controlling electrical distribution systems like EPMS software is.

BMS software

BMS software is designed for monitoring, controlling and reporting on smart building technology systems, including access control, video surveillance, smart space management, fire & safety, heating, ventilation, air conditioning (HVAC), programmable lighting, transportation (elevators, escalators, moving walkways), and pumping systems.

Although BMS software can acquire real-time power measurement data from electricity metering devices, it lacks any specialized applications for power events analysis or utility bill verification and is not designed for power management. Most BMS platforms have visualization and reporting capabilities for tracking energy usage but not to the degree that EMS software provides, especially in the areas of energy usage analysis, energy modelling, energy billing, and energy data integrity validation.

Tenant billing software

Tenant billing software is specialized software that reads consumption data from tenant meters and submeters and automates the process of bill creation, distribution and tracking. Some tenant billing software is still on-premise but most tenant billing solutions are cloud-based which means that data concentrators and IoT gateway devices are needed on-premise to read data from the tenant meters before they push it to the tenant billing platform in the cloud.

Enterprise software

Some enterprise software platforms acquire and make use of energy consumption data but they do not get it directly from the metering devices – instead they retrieve it from other systems or, in some cases, the data is pushed to them by other systems. The most common examples include:

- Enterprise resource planning (ERP) software
- Integrated workplace management system (IWMS) software
- Enterprise energy management (EEM) software
- Industrial data management software

ERP software

ERP software centralizes multiple business processes into a single environment, including human resources (HR), customer relationship management (CRM), business intelligence (BI), supply chain management (SCM), inventory management and accounting/financial management. Most ERP systems collect energy spend data but only some collect energy consumption data. Departments such engineering, accounting, property management, and corporate management use ERP energy data to identify poor performing systems/equipment, track overall building performance, and report sustainability performance and ESG (environmental, social and governance). ERP energy data is also commonly used for budgeting purposes and purchasing energy, but ERP systems do not provide insights about load profiles, weather nominalization or building benchmarking that would otherwise help reduce energy costs.

IWMS software

IWMS is an enterprise-scale software platform that supports IT, facilities management and real estate professionals to manage the end-to-end life cycle of corporate facilities, assists in cost containment and helps optimize the use of workplace resources to provide an improved employee experience. Most IWMS systems exchange data with other systems such as ERP, BMS, and EMS systems. Cost centers, budget codes and supplier information are examples of data frequently exchanged between ERP and IWMs. Technical data from BMS and energy usage data from EMS are regularly retrieved and used by IWMS platforms. Energy usage data is mostly used to reduce costs, improve efficiency and track building performance.

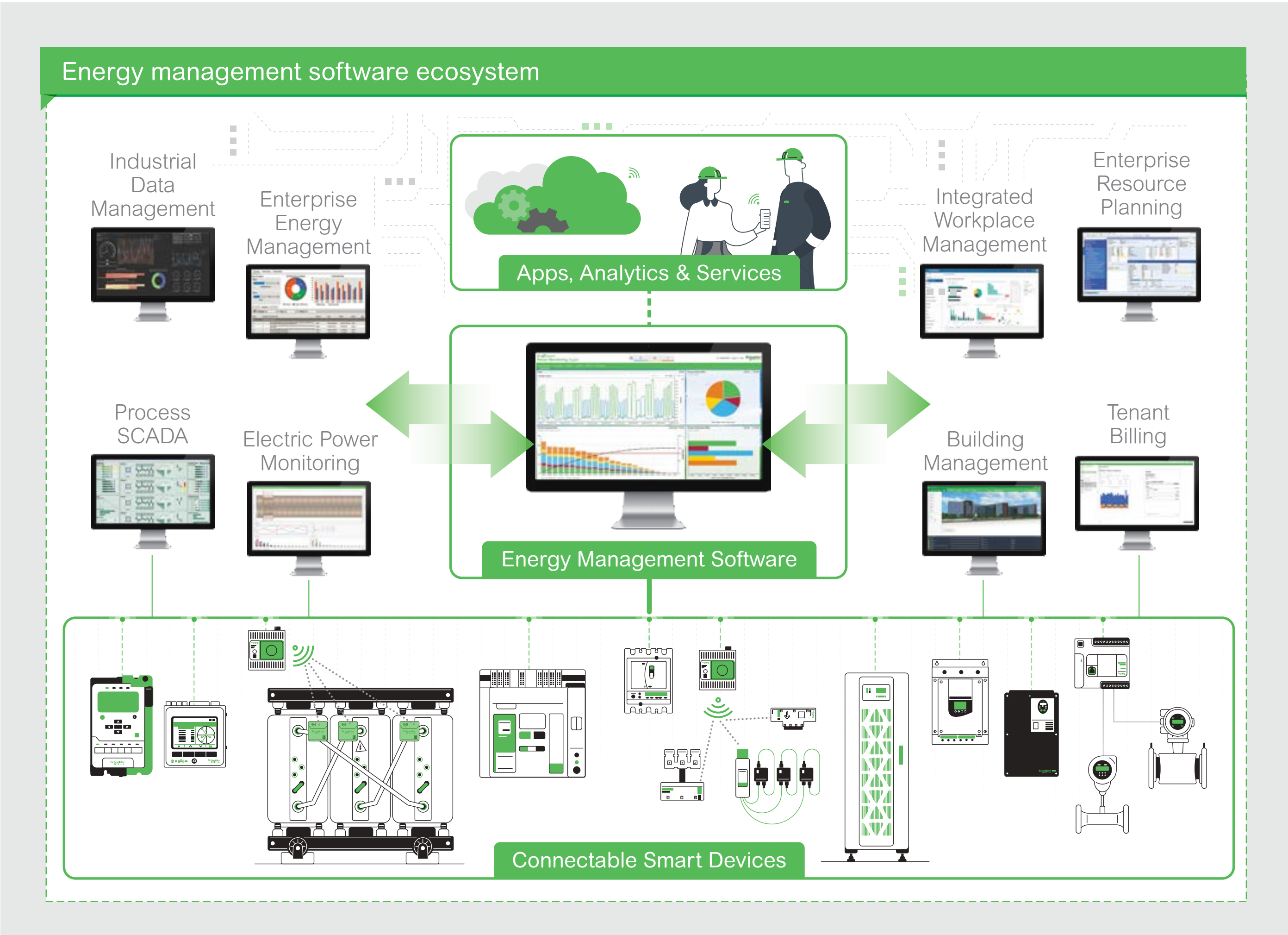
EEM software

EEM platforms collect energy data from multiple data sources, such as EPMS, EMS and BMS systems, from across a portfolio of sites. Typically, the data is consolidated into a centralized data warehouse where it is processed, structured and optimized for business intelligence (BI), analytics and reporting. Traditional EEM platforms are on-premise, but most are cloud-based today. EEM software makes data-driven energy information available to various stakeholders within an organization ranging from energy managers, facility managers, and engineers to department heads, financial staff, and executive management.

Industrial data management software

Industrial data management software collects, stores, and contextualizes real-time industrial data for remote monitoring, analysis and sharing. These software platforms can be on-premise or cloud-based. They connect to real-time data streams to collect raw data and then consolidate, cleanse and organize it into a single system of record. Most industrial data management software provides self-service data visualization tools and can identify anomalies and send alerts. These platforms are also designed to share their data, including power measurement and energy usage data, with other applications, such as Microsoft Power BI or Granfana giving analysts self-service access to consistent operations data and related contextual information. Some organizations are using industrial data management software to offer new services to their clients and build a network of interlinked partners to create new business value.

Investing in a comprehensive electricity metering infrastructure is crucial for efficient and reliable building operations, active energy management, and carbon reporting. Energy usage data generated by electrical metering devices can be used by various software systems for different applications. When designing a metering system, it is essential to consider the type and number of software systems that will communicate directly with the meters to acquire data. On-premise supervisory management systems generally use the Client-Server communication architecture, where the software acts as the client, and devices act as servers, providing data only when requested. The convergence of OT and IT has led to the development of metering system architectures that leverage WiFi and cellular networks to get metering data to cloud-based software platforms. Metering data can be sent directly to the cloud or acquired by on-premise data concentrator devices before being sent to the cloud. Furthermore, many on-premise supervisory software platforms can also send their metering data to the cloud. Overall, an effective metering system that provides accurate and timely data is necessary for optimizing building performance, reducing energy consumption and costs, and achieving sustainability goals.



Electricity metering communications and I/O

The primary reason digital electrical metering devices are installed in buildings is to collect power measurement and energy usage data and share it with other devices, software systems and remote applications via communications. Specifying communication and I/O options for a metering device and selecting an appropriate metering communication topology requires a good understanding of the number and type of clients (other devices, software and applications) that may need to retrieve data from the metering device and the digital applications that the meters will be serving.

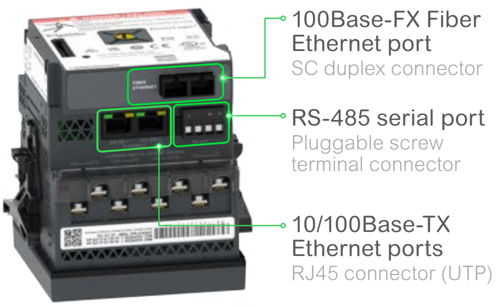
- Will there be more than one application/software system regularly polling the meter?
- Does the meter need to provide its data to different systems using different protocols?
- Is the meter going to be used for any time-sensitive applications that involve alarming or power event analysis?
- Is the meter going to be collecting information from other devices in the network?
- Is the meter going to be used as an input metering device for collecting energy usage data from other meters (water, gas, electricity, steam and heat meters)?

Ethernet and RS-485 serial communication

There are many differences between Ethernet and RS-485 serial communications. Ethernet is considerably more sophisticated and is the global standard for IT networks. Ethernet is also used as the communications backbone for industrial OT networks, but RS-485 serial data busses are still used to connect instruments, motors, sensors, drives and controllers to the OT Ethernet network. However, the trend is clearly moving towards using direct Ethernet connections for these kinds of industrial monitoring and control devices because **Ethernet offers so many benefits, including flexibility, interoperability and performance**.

Most Ethernet-enabled industrial monitoring and control devices support 100Base-TX connections using standard RJ45 connectors. However, some devices may also support fiber-optic Ethernet connections (100Base-FX) which provides immunity to electro-magnetic interference (EMI) and has a maximum cable length of 2000m, far exceeding the 100m cable length maximum of 100Base-TX connections. For these reasons, fiber-optic Ethernet connections are often specified in high EMI environments, industrial settings or when the distance to the nearest Ethernet switch is greater than 100m.

Types of communication ports

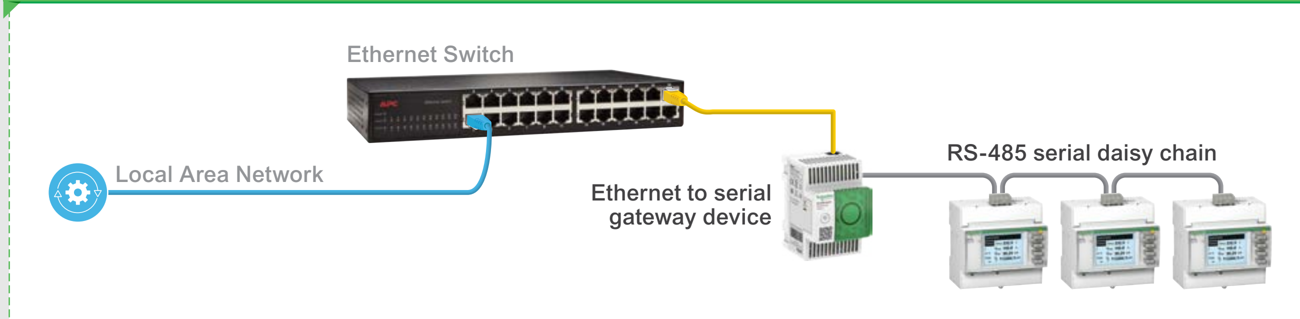


For digital metering applications, the most significant advantages of direct Ethernet connections are:

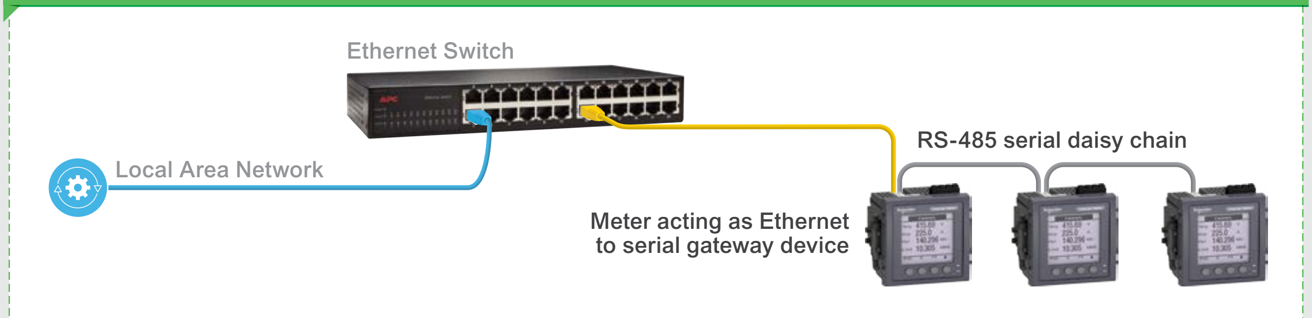
- Much faster data transmission rates (10 Mbps, 100 Mbps)
- Multiple, concurrent connections
- Multiple data communication protocols (Modbus TCP, BACnet/IP, DLMS, IEC61850)
- SNMP for interfacing with IT management systems
- Create redundant network loop using Rapid Spanning Tree Protocol (RSTP) and managed Ethernet switches
- NTP and PTP for synchronizing the clock onboard the meter
- HTTP/HTTPS for sharing onboard webpages via a browser
- FTP/SFTP for pushing data files (e.g. Comtrade waveform files) from the device
- SMTP for sending email alerts directly from the device

Electrical metering devices can be connected to an Ethernet local area network (LAN) directly or via an Ethernet gateway device if the metering device only supports RS-485 serial communications. Serial communication ports can only support one data protocol and RS-485 serial daisy chains can only serve one request from one client at a time. Even though RS-485 serial busses can support up to 32 devices (nodes), it is strongly recommended to **limit the number of meters in a serial daisy-chain to a maximum of 10 to ensure reasonable data transmission rates**. If a meter is required to provide data to more than one client using different protocols, (e.g. Modbus and BACnet), then a direct Ethernet connection should be specified. Common meter communications topologies are shown below:

Serial connected via an Ethernet gateway device



Serial connected via an Ethernet direct connected meter

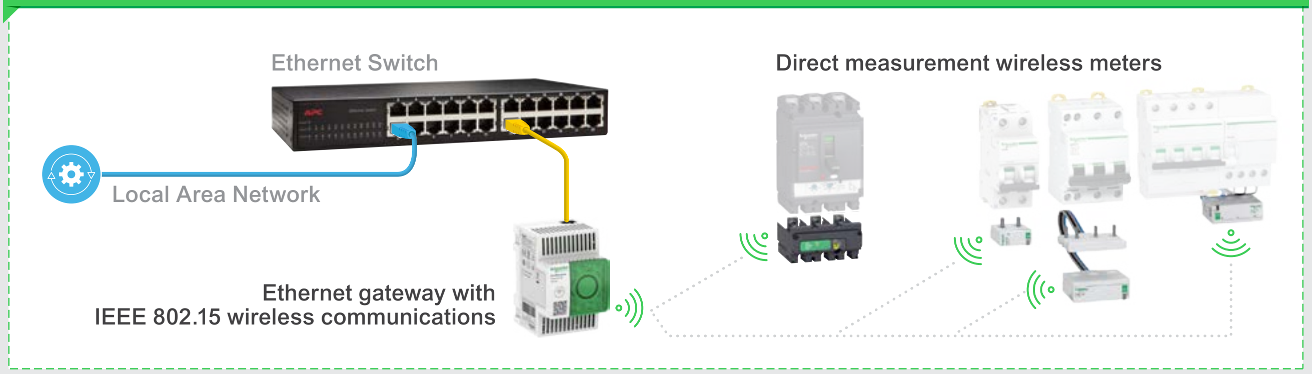


Wireless communications

Instead of using traditional wired communications, some power meters can transmit their data to nearby gateway devices using wireless communications. Several wireless communication standards exist, but the one best suited to transmitting power data from multiple meters to a nearby gateway for monitoring and control applications is Zigbee (IEEE 802.15.4).

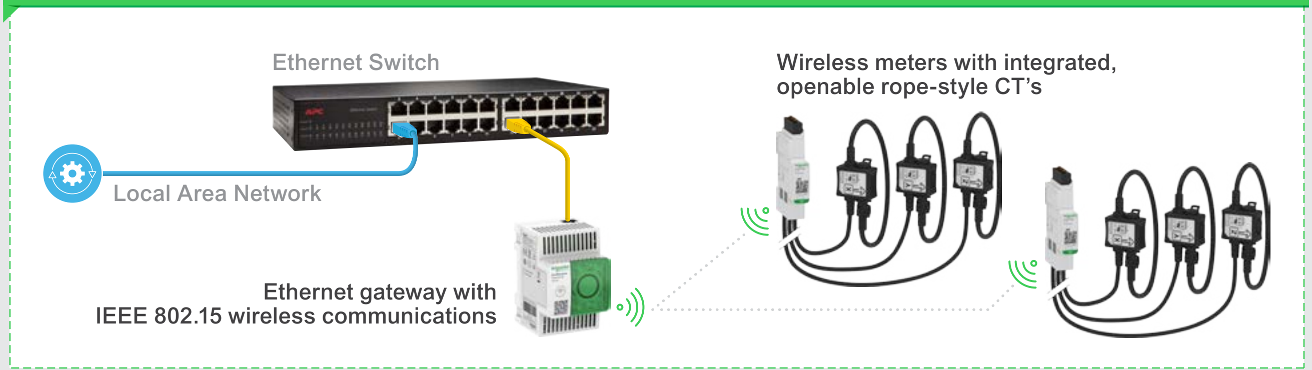
Embedded metering systems with wireless communications are relatively new but are proving to be highly effective for final distribution metering applications. The power meters in these systems are designed to mount directly onto molded case circuit breakers (MCCBs) and miniature circuit breakers (MCBs) inside low voltage electrical panels without the need for current transformers or control power. Their small size means they can be installed in almost any panel with no need for additional space. And because they transmit their data wirelessly to a nearby gateway device, there are no communication wiring requirements except for an Ethernet connection for the gateway device.

Embedded wireless metering systems for final distribution



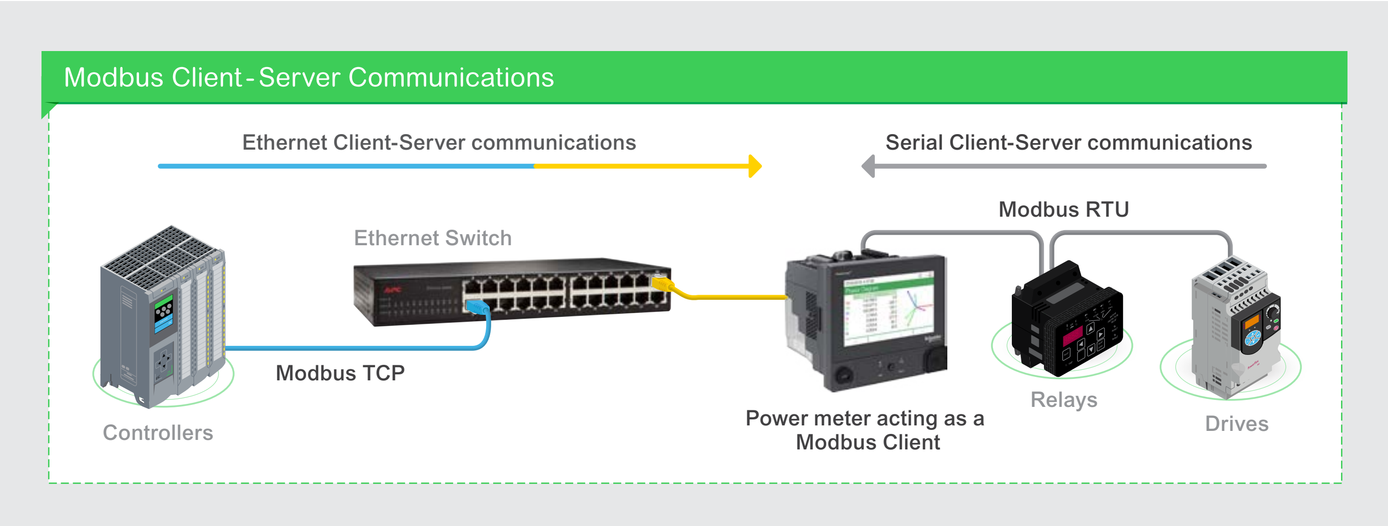
Wireless power metering devices can also be used to monitor primary/secondary distribution panels and large loads (between 200 amps and 2000 amps). In these cases, instrument current transformers (CTs) are required, so it is recommended to choose a self-powered meter that has integrated, openable rope CTs that can be installed without disconnecting the conductors (busbars or cables).

Wireless metering systems for large (200 – 2000 amps) circuits



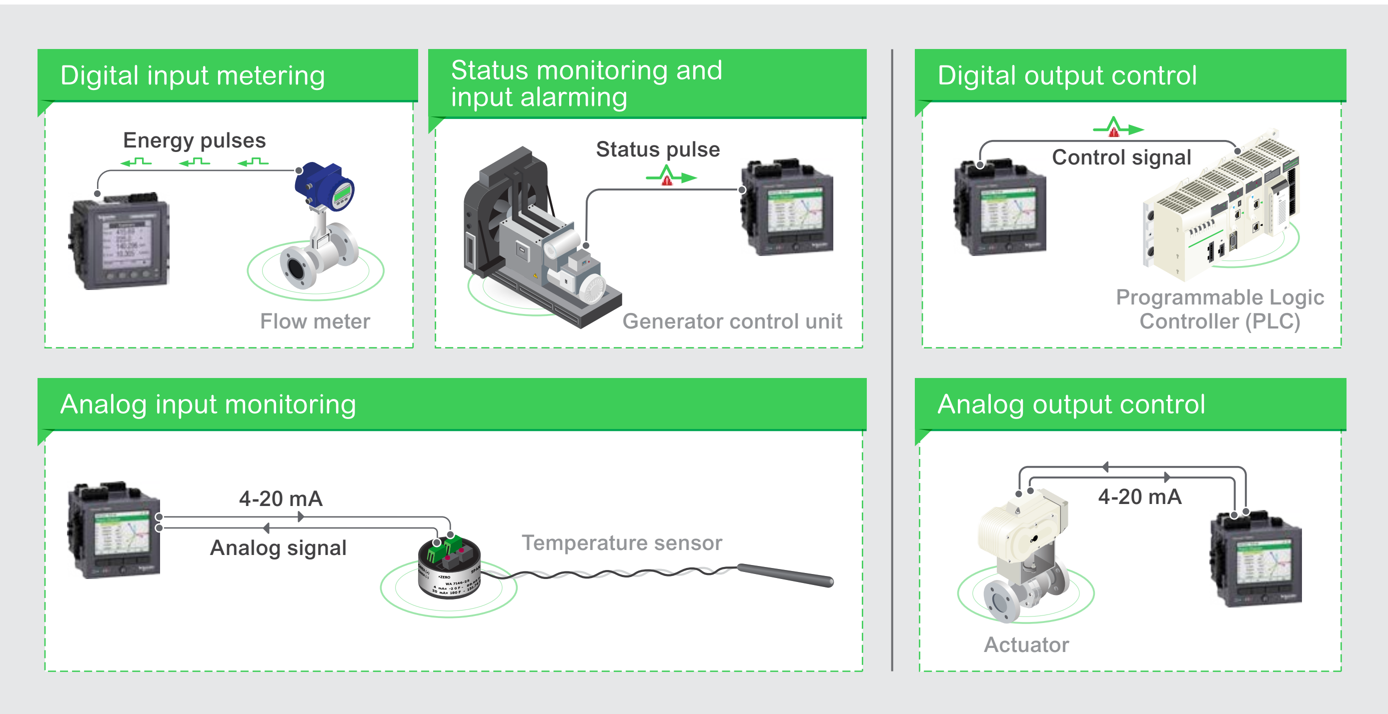
Modbus Client-Server communications

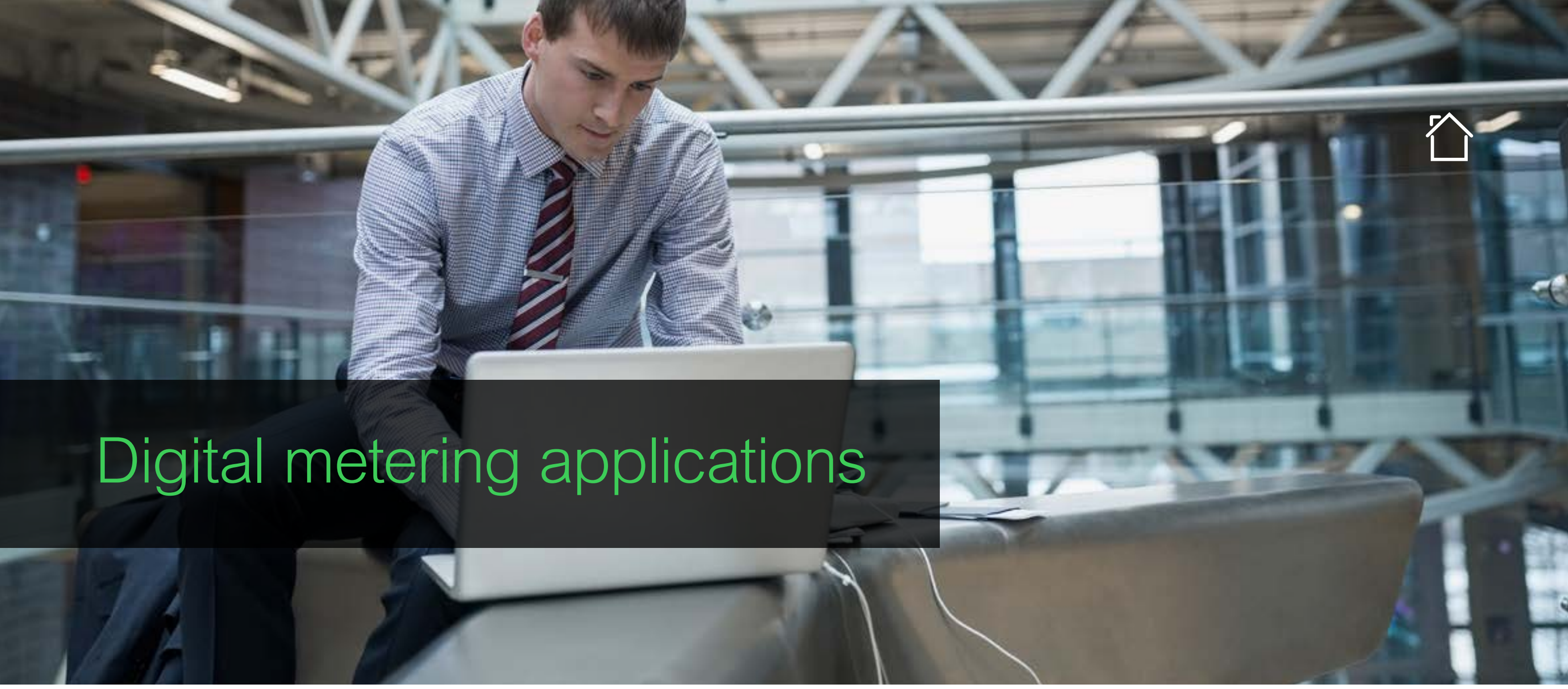
Some power meters can function as a Modbus Client (formerly called Modbus Master) with the ability to send read/ write commands to other Modbus communicating devices in the same network. This communication method can be used to collect additional information (reading Modbus registers) and/or control other devices (trigger, reset, toggle via Modbus write commands). Some power meters can only act as a Modbus Client to downstream devices on a RS-485 serial bus while others can also act as a Modbus Client over the Ethernet LAN via Modbus TCP.



Input and output options for metering devices

Some power meters come equipped with digital/analog inputs for collecting information from other meters (water, gas, electricity, steam and heat), devices or equipment. Some power meters also support digital/analog outputs for transmitting information to other devices or controlling equipment.





Digital metering applications

Smart electrical metering devices are the source of electrical energy usage data and power quality information. Collecting energy usage data is an essential requirement for many building energy codes & regulations, energy management standards and green building programs. Energy usage data also serves as the foundation for driving the direction of energy efficiency and sustainability programs, and measuring their success. In addition, power measurement information is often used by engineering teams and facility management personnel for electrical system operations & maintenance as well as for troubleshooting electrical problems and issues with equipment. When combined with EPMS and EMS software, energy & power measurement data collected from electrical metering devices can unlock many valuable digital applications that help organizations accomplish their sustainability goals and reduce operating costs while maximizing power availability.

90%

of countries are now covered by some kind of net-zero target, with a total of US$130 trillion of assets committed to this goal.

Corporate Knights

Sustainability applications

Worldwide, institutions and companies are establishing energy management systems with comprehensive electricity metering to help provide energy usage visibility. In so doing, they can improve energy efficiency, lower energy costs, achieve a high green-building rating and reduce GHG emissions. Energy efficiency activities organized as part of an energy management system are proven to lead to persistent improvement in energy performance and represent best practice in meeting energy reduction targets.[11] In addition, building energy codes and regulations are being developed, updated, and implemented all around the world. As a result, engineering, design, & consulting firms are under increasing pressure to keep pace with the latest smart electrical distribution architectures and power management technologies to deliver solutions compliant to todays' energy codes & regulations and meet the sustainability and carbon reduction goals of their clients.

[11] **Energy Management Systems Support the Better Climate Challenge**, U.S. Department of Energy FAQ

Compliance to energy codes, regulations, and green building programs

Most energy codes, regulations, standards, and green building programs do not specify how to capture energy usage data, only that it must be done for the purposes of **energy usage tracking and reporting on a periodic basis**. Some energy codes will stipulate that metering devices have onboard data storage capacity to hold energy data for a minimum duration (e.g. 90 days). From a digital metering application perspective, the most important factor for complying to building energy codes, adhering to building performance regulations and attaining green building certification is having **power measurement devices in the right locations** throughout the electrical network to capture the data necessary **to report electrical energy usage by load category**. It is recommended to leverage existing ancillary power measurement devices (protection relays, breaker trip units, UPSs, VSDs) to acquire energy data; however, it is likely that dedicated power meters will also be needed to collect energy usage data from locations where ancillary metering devices do not exist – especially on final distribution circuits that serve common building load categories (e.g. HVAC systems, interior lighting, exterior lighting, receptacles, appliances, etc.).

Energy monitoring, performance, and verification

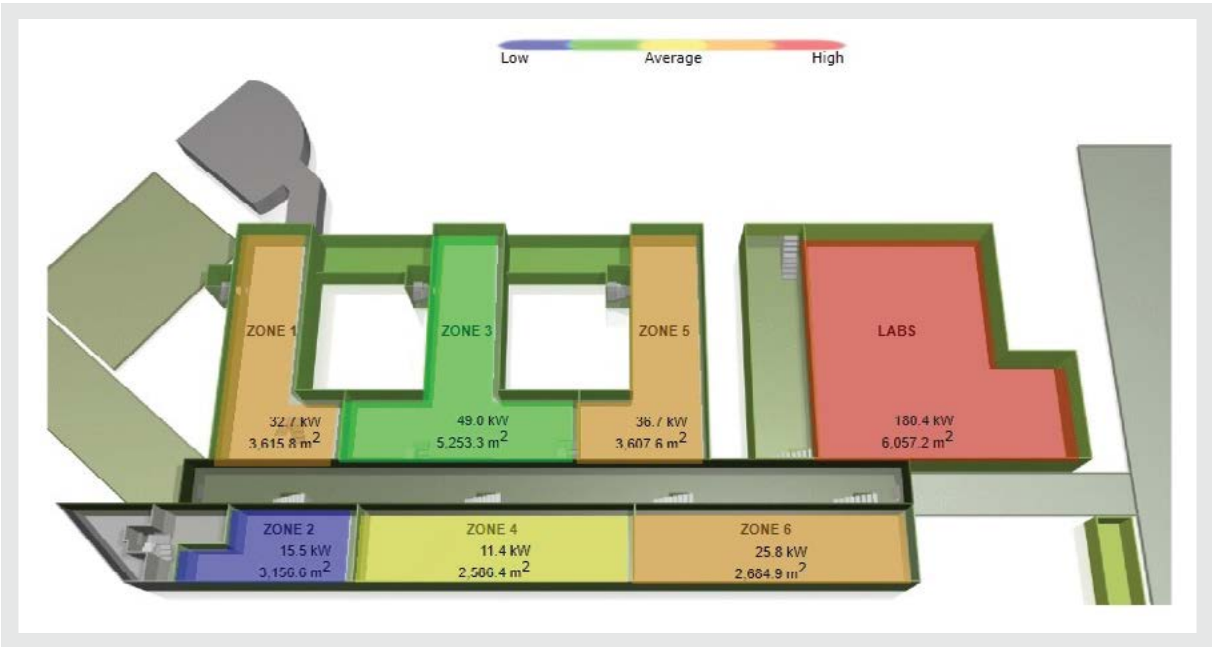
Reducing energy waste and improving energy efficiency is a key part of any sustainability plan and is best accomplished with an energy management system in place to support it.[12] Electrical metering devices play an essential role in energy management as they enable the ongoing collection of energy usage data needed for understanding where and how energy is being consumed throughout a building, providing the necessary data to track and verify energy performance.

Example of a energy usage analysis dashboard in EMS software

[12] ISO 50001 Energy management

When specifying electrical power metering devices for energy monitoring, performance, and verification purposes, **it is crucial to know where to measure to get the power measurement data required for calculating key energy performance indicators.** It is also important to use energy management software that can normalize energy usage data and track energy consumption in the context of environment (e.g. temperature) and operations (e.g. occupancy, production, etc.), because raw energy consumption data can be very misleading and by itself is not a good indicator of energy efficiency.

Example of a real-time energy usage intensity monitoring screen in EMS software



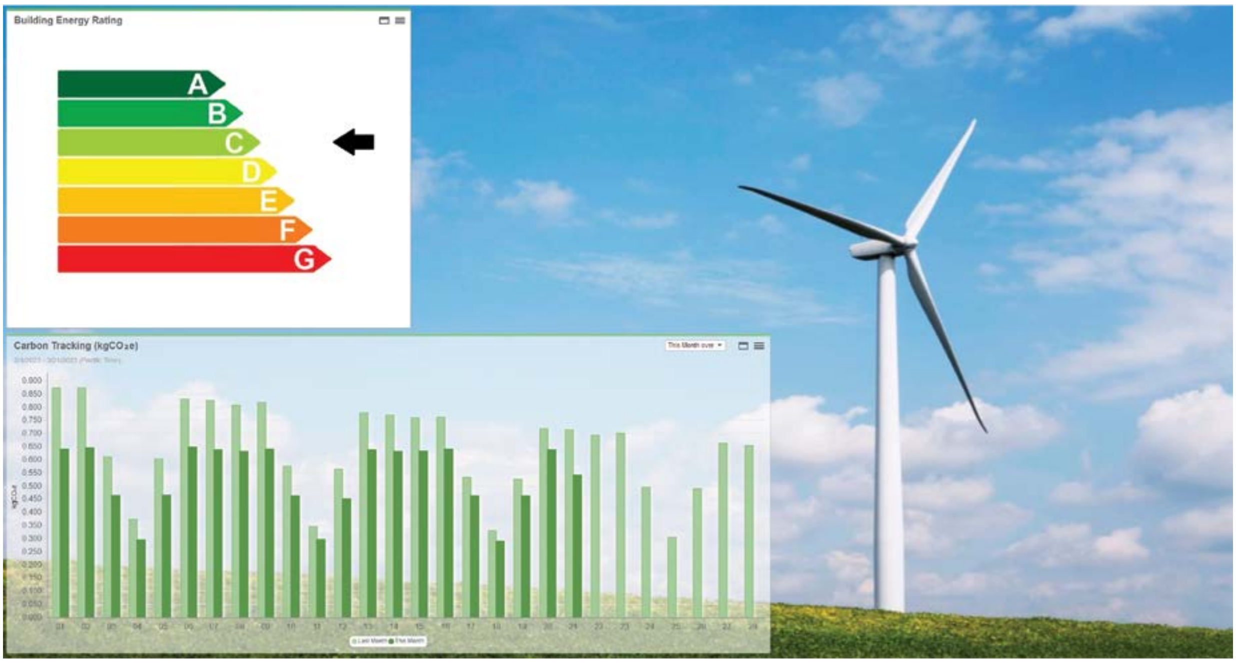
Greenhouse gas and carbon reporting

Organizations are under increasing pressure to track and report their Corporate Carbon Footprint as per the GHG Protocol. Measuring the total electrical consumption of a facility is an essential part of calculating GHG Protocol Scope 2 indirect emissions. This can be accomplished by using consumption data provided by the electric utility or by metering the electrical service entrances with customer-owned power meters. Many companies and institutions also want to report their energy reduction performance in terms of reduced carbon emissions. In order to do this, energy consumption units (e.g. kilowatt-hours [kWh]) need to be converted into carbon emission units (e.g. kilograms CO_2 emissions [kg CO_2]). From a power metering standpoint, any device that can accurately measure electricity usage in terms of kWh may be used for energy performance monitoring which can then be converted to carbon emission units for GHG and carbon reporting. Most energy management software platforms can convert energy units into GHG emission units for tracking and reporting purposes. Converting kWh to kg CO_2 is a straightforward calculation using an electricity emission intensity factor. These conversion rates are readily available for most parts of the world and are typically published by government environmental agencies.

From a power metering standpoint, **any device that can accurately measure electricity usage in terms of kWh may be used for energy performance monitoring which can then be converted to carbon emission units for GHG and carbon reporting.** Most energy management software platforms can convert energy units into GHG emission units for tracking and reporting purposes. Converting kWh to kg CO_2 is a straightforward calculation using an electricity emission intensity factor.

These conversion rates are readily available for utility electricity grids for most parts of the world and are typically published by utilities and government environmental agencies. The United Nations Framework Convention on Climate Change publishes a Methodological tool for calculating the emission factor for a utility electricity system.[13] Calculating an emission factor for local on-site power generation (solar, wind, fuel cell, etc.) and for an on-site backup power system (diesel/gas generators) would follow the same principals but these estimations would have to be made based on the specific attributes of the on-site power sources.

Example of an energy efficiency and carbon tracking dashboard using EMS software



[13] Emission factor calculation tool, United Nations Framework Convention on Climate Change.

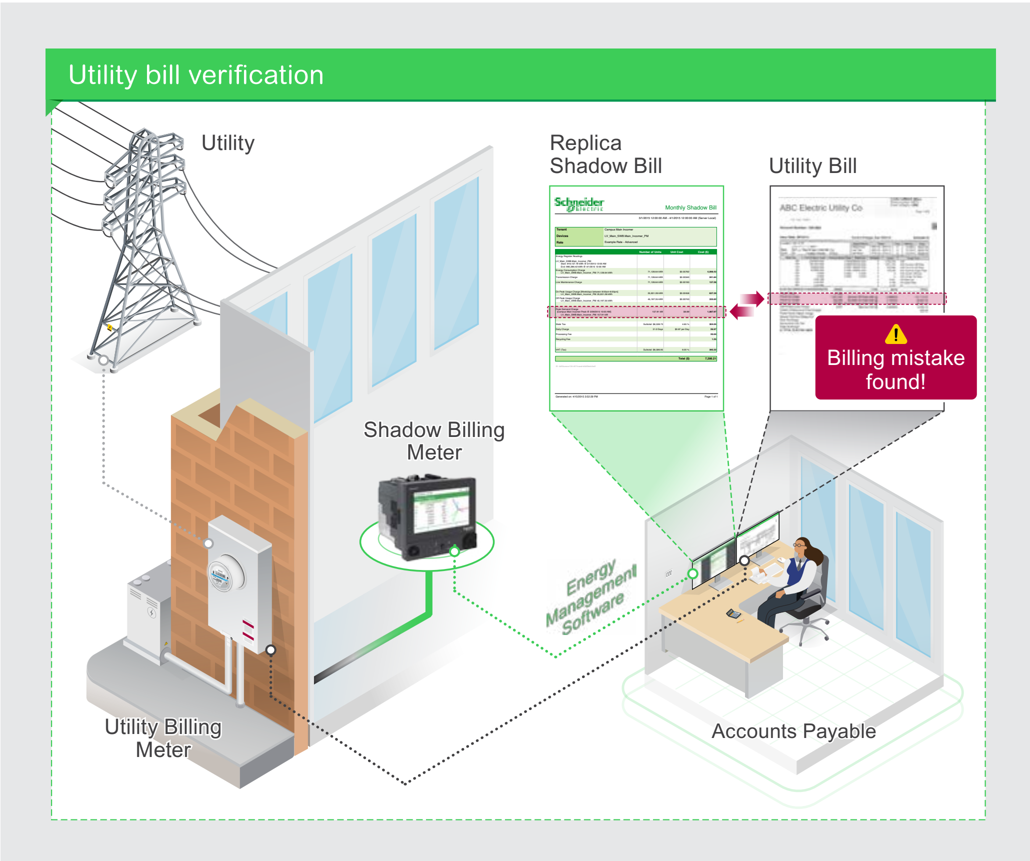
Utility bill verification

Utility billing mistakes happen more often than people think. The consequences can be expensive. Unfortunately, most organizations do not have a process in place to verify each utility bill they receive is free from errors. One reason is because electricity rate structures can be quite complex, making it challenging and time-consuming to verify every billing line item is correct. Utility bill verification is a digital metering application that automates the creation of a replica utility bill, allowing a person to visually inspect their real utility bill and verify each line item is correct and free from mistakes. For this application, a "shadow billing" meter is installed downstream from the utility billing meter on the same main feeder. This application also requires software that can apply complex utility rate structures to the data collected by the "shadow billing" meter and generate detailed replica utility bills for the end user. The figure below provides an overview of the utility bill verification application.

$123k

average cost of large-account billing errors

[Wisconsin Public Service - Thousands of utility customers wrongly charged]



80%

of companies are overcharged on utility expenses.

[National Utilities Refund]

This same approach can be applied to verifying water and gas bills as well.

Energy cost allocation

Some organizations need to allocate energy costs to groups/departments for internal accounting or charge-back purposes. Others want to track energy costs by process, asset, or product for optimizing operational expenses, understanding the true cost of goods, and maximizing profits. The scope and complexity of energy cost allocation applications can vary widely depending on a few main factors:

- Number of different forms of energy (water, air, gas, electricity, steam)
- Number of measurement points required for the desired reporting scope
- Complexity of the energy cost calculations (flat rate, tiered rates, allocating demand & power factor charges, Time-of-Use, cost of local power generation, etc.)
- Reporting interval (every minute, hour, day, week, month)

Regardless how complex an energy cost allocation becomes, the requirements for the electrical metering devices remain basic because the factors listed above are addressed with energy management software.

Sub-billing and tenant billing

In most parts of the world, the use of power measurement devices for billing purposes is regulated by a local, regional or national government agency and is often considered a legal metrological application, just like a meter in a taxi cab or a petrol pump machine at a petrol filling station. The collection of power measurement data used for billing applications is still a very basic process in many places (manual meter readings, manual data downloads from meters, manual data copying into a billing software system or a billing data repository), which is why most specifications for "electricity billing" meters require onboard storage of energy usage data.

Usually, billing meters possess special features related to security and anti-tampering, Time-of-Use (TOU), and they must be compliant to local regulations and accuracy standards. In some jurisdictions, only "certified" meter models can be used for billing purposes (e.g. Measuring Instruments Directive [MID] for EU & UK, Division of Measurement Standards [DMS] for the state of California, New York Public Service Commission [NYPSC] for the state of New York, Measurement Canada for Canada, National Measurement Institute [NMI] for Australia).

Metering requirements for sustainability applications

The metering requirements for most sustainability applications are quite basic. For **compliance to energy codes, regulations, and green building programs**, **energy monitoring, performance, and verification** and **greenhouse gas and carbon reporting applications** it is recommended to specify the following meter requirements:

- Easy-to-install and simple to configure
- Small footprint with minimum space requirements
- Direct measurement meter where possible – no external current transformers (CTs)
- Self-powered or minimum requirements for power supply (control power)
- Wireless communications or minimum requirements for communications wiring
- Four-quadrant, bi-directional real-time energy measurements
- At least 30 days onboard data storage for energy measurements
- Support for Modbus and/or BACnet communication protocol
- Optional digital inputs for external pulse metering applications
- Responsibly manufactured, green product with stated embedded carbon content
- Designed to last with a declared mission profile at least 10 years

In addition to the above features, meters that will be used for **energy cost allocation applications** should also possess the following:

- Power demand and interval energy measurements
  (kW, kVA, kVAr demand & kWh, kVA, kVAr interval energy)
- Time-of-Use (TOU) energy measurements
- Time-synchronizable onboard clock
- At least 0.5% accurate for active energy

In addition to the above attributes, meters that will be used for **sub-billing and tenant billing applications** should be compliant / certified to local billing meter regulations and have:

- Secure user access control
- Anti-tampering features

Meter features – sustainability applications reference table

Sustainability Applications	Energy Reporting	Energy Cost	Billing
Four-quadrant, bi-directional real-time energy measurements (kWh, kVAh, kVAr - in, out, net, total)	✓	✓	✓
At least 30 days onboard data storage for energy measurements (some regulations >30 days)	✓	✓	✓
Support for Modbus and/or BACnet communication protocol	✓	✓	✓
Optional digital inputs for external pulse metering applications (water and gas input metering into power meter)	✓	✓	✓
Power demand and interval energy measurements (kW, kVA, kVAr demand & kWh, kVA, kVAr interval energy)		✓	✓
Time-of-Use (TOU) energy measurements		✓	✓
Time-synchronizable onboard clock		✓	✓
At least 0.5% accurate for active energy		✓	✓
Secure user access control			✓
Compliant / certified to local billing meter regulations			✓
Anti-tampering features			✓

Energy Reporting
- Compliance to energy codes & regulations, and green building programs
- Energy monitoring, performance, and verification

Energy Cost
- Energy cost allocation
- Utility bill verification

Billing
- Sub-billing and tenant billing

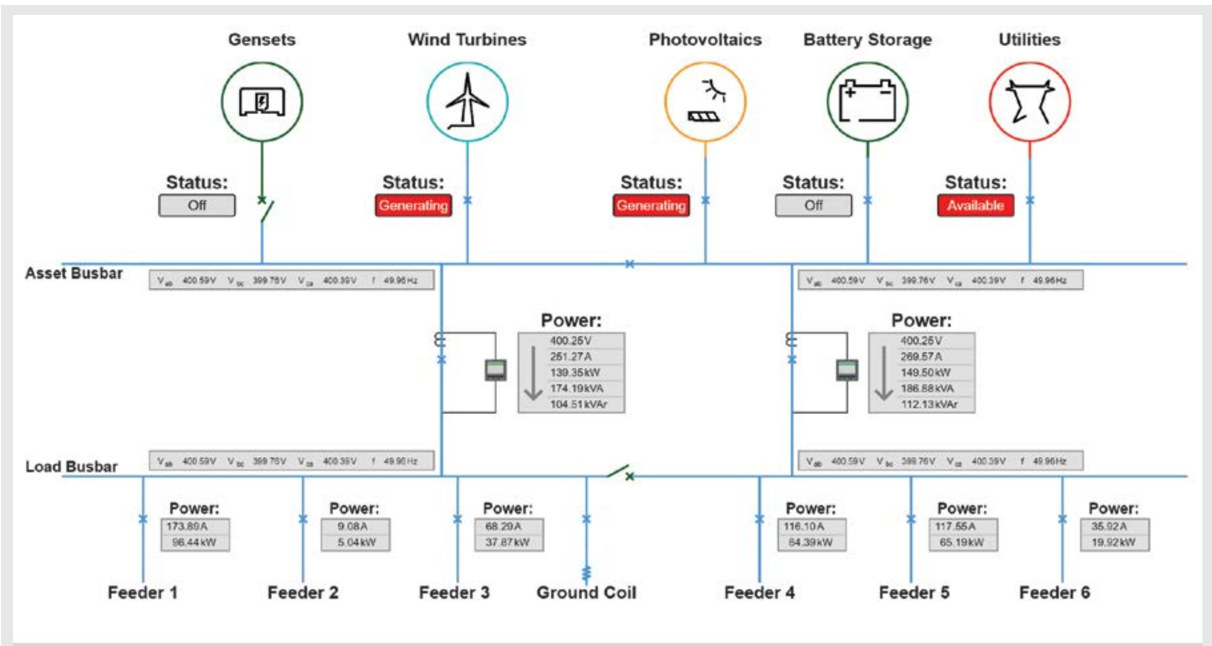
Power availability applications

In addition to capturing energy usage data for improving energy efficiency and helping track carbon emissions, power metering devices are also used for real-time power monitoring, managing electrical capacity, testing backup power systems, monitoring power quality parameters, and diagnosing electrical problems.

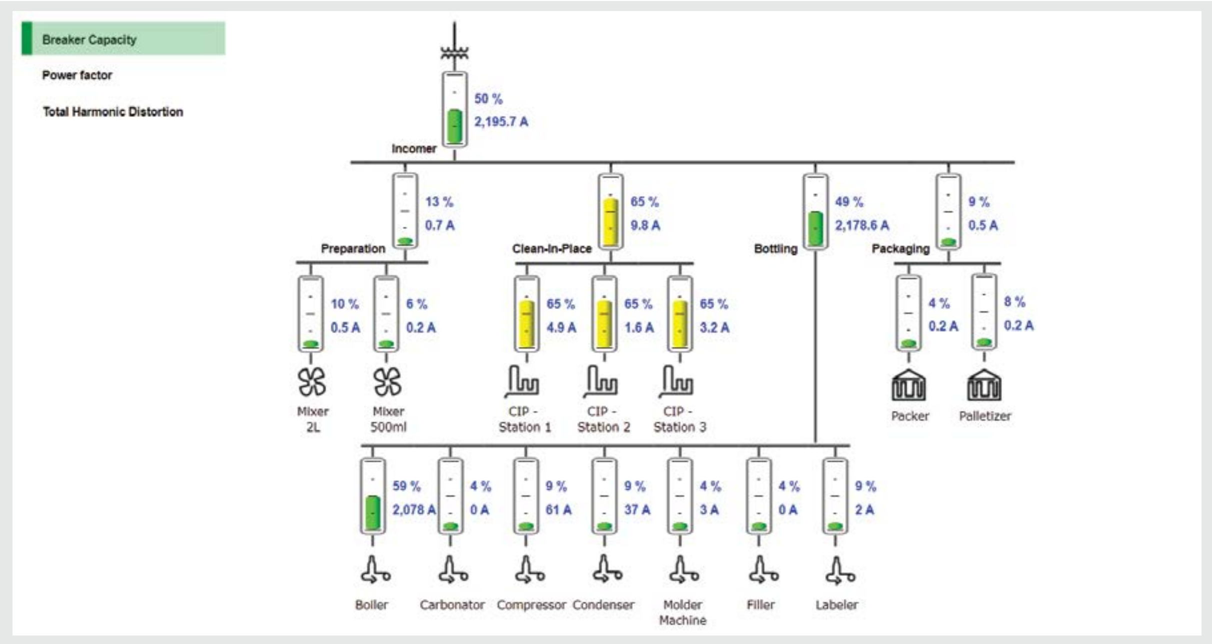
Power monitoring and electrical capacity management

As buildings become more electric and dynamic with onsite renewable power generation, energy storage, backup power systems, electric HVAC systems, increasing IT and EV charging loads, and interactivity with the power grid, the need for real-time power monitoring and electrical capacity management increases. Electrical metering devices provide the real-time and historical data needed to operate and maintain grid-interactive buildings with flexible energy systems. They are used to track how much power is being generated by onsite generation sources compared to how much is being drawn from the grid and they are used for load management, providing the data needed to understand how much power is drawn by different types of loads under various conditions.

Example of a real-time power monitoring screen in EPMS software



Example of a real-time capacity management screen in EPMS software



Power monitoring and capacity management requires the following electrical measurements to be recorded at strategic points in the electrical system:

- Per phase voltages and voltage imbalance
- Per phase and total current (A)
- Per phase and total active power (kW)
- Per phase and total apparent power (kVA)
- Per phase and total reactive power (kVAr)
- Power Factor

Any dedicated power meter or ancillary metering device that can provide these measurements to power and energy management software over a local area communications network via an industry standard data protocol (e.g. Modbus, BACnet) can be used for this application. A well-implemented power monitoring and capacity management application can:

- Monitor real-time power measurements per circuit
- Alarm on loss of voltage (any phase), voltage imbalance and over current conditions
- Trend and report historical loading on circuits
- Compare peak power demand between different circuits
- Provide pre-defined reporting for equipment capacity (transformers, generators, circuit breakers and UPSs)
- Simplify capacity planning for operation expansion or modification
- Avoid oversubscribing critical equipment

Electrical health diagrams

can provide an intuitive, graphical view of the network health, in terms of capacity, power factor, and harmonics. It is possible to monitor real-time and historical data in the trend viewer. With various report templates for UPS, generator, equipment, and branch circuits, Facility Managers have the right tools to analyze capacity at every node in the network.

Backup power system performance monitoring and testing

Facilities rely on backup power systems to supply power to the most important loads when the main power supply (usually from the electric utility) is disrupted or lost. Automatic transfer switches (ATSs) are specialized equipment that intelligently and automatically manage the transfer of power between the primary power supply and the backup power supply. Most backup power systems are generator-based (reciprocating engines and gas turbines) that need some time to power up before they are ready to provide acceptable electrical power to the network, resulting in a short power outage (a few seconds to a couple minutes). Uninterruptible power supplies (UPSs) are installed on circuits that serve critical loads to ensure power supply is always available, even during transitions to backup power supply.

For backup power system performance, the real-time status of ATSs, backup generators/turbines, and UPSs should be monitored. It is also important to capture the following electrical measurements before, during and after a transition to/from the backup power system:

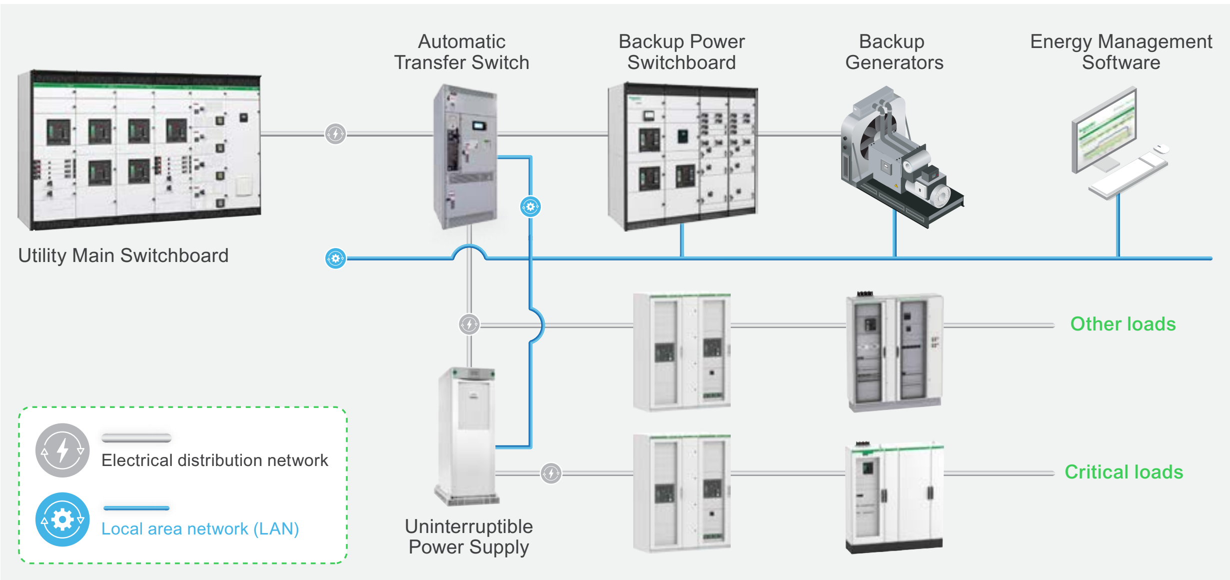
- Phase voltages (line to neutral / line to line)
- Per phase current
- Total power (kW) and total apparent power (kVA)
- Power Factor
- Frequency

20-30%

of backup power systems fail to start. Common causes include starter battery failure, low fuel levels, wet stacking, improper control settings.

Electric Power Research Institute (EPRI)

Backup power system architecture



When specifying power meters for backup power performance monitoring, it is recommended to include the following features in addition to the basic power measurements listed above:

- High speed triggers for alarms (½ cycle resolution or better)
- High speed data logging (½ cycle resolution or better)
- Time synchronizable onboard clock (at least 1 ms timestamp resolution)
- Support for IRIG B, NTP and PTP time synchronization protocols
- Digital and analog inputs for capturing equipment status information
- Support for custom programming to create additional applications

Power quality monitoring and power event analysis

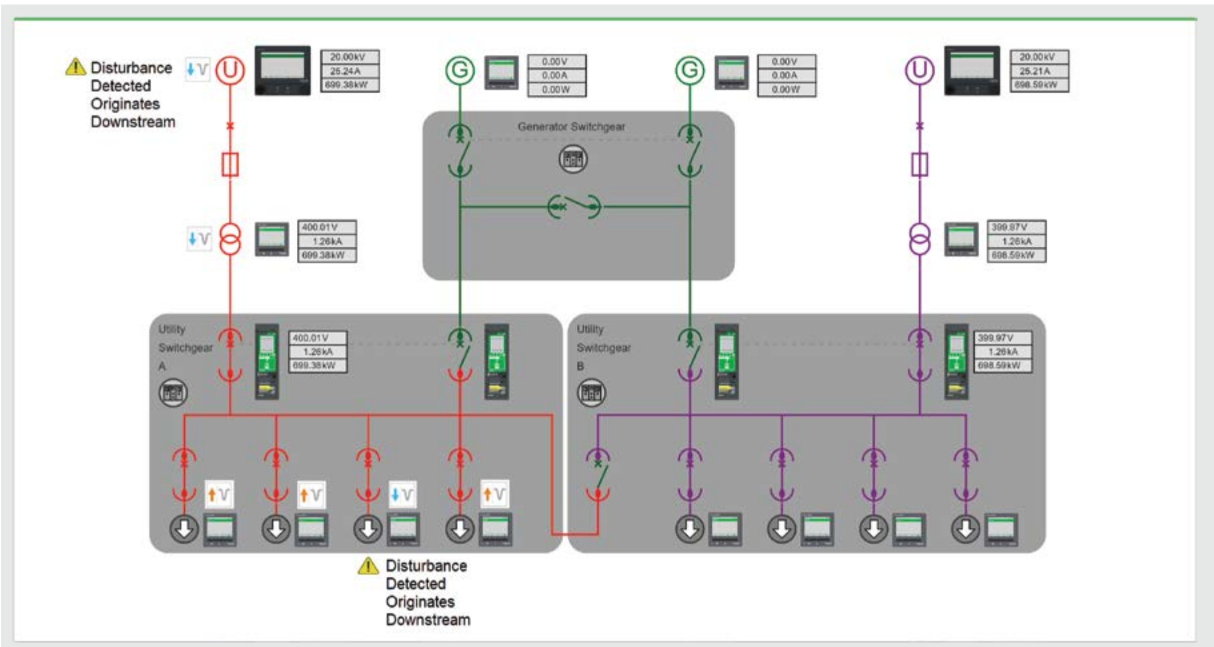
Over-voltage and under-voltage conditions and phenomena such as voltage transients, sags, swells, imbalance, harmonics and flicker are common and they can adversely affect equipment behavior and performance. Continuously measuring, understanding, and acting on these disturbances is key to limiting equipment damage and minimizing unplanned downtime. Power quality disturbances can originate from within a facility or they can be introduced into a building from the electrical power grid.

75%

of facilities have unrecognized power quality issues.

Results from a Schneider Electric study of more than 500 energy and power monitoring systems - 2017

Example of power quality disturbance monitoring using EPMS software



Power quality monitoring and event analysis provides valuable insights about the origin, impact, and frequency of different types of power quality disturbances and is necessary to verify that harmonic levels are not exceeding the limits specified by IEEE Standard 519-2022 and can be used to confirm the quality of utility power supply complies with EN 510160.

Power quality monitoring and analysis applications require advanced, dedicated power meters with the following attributes:

- Certified 0.2% accurate or better
- IEC 61000 4-30 Class A compliant
- At least 1024 samples per cycle sampling rate
- High speed voltage disturbance detection with waveform capture on each phase and neutral circuit
- Onboard analytics to determine the direction of voltage transients, sags and swells relative to the meter (Disturbance Direction Detection)
- High speed triggers for alarms (½ cycle resolution or better)
- High speed data logging (½ cycle resolution or better)
- Time synchronizable onboard clock (at least 1 ms timestamp resolution)
- Support for IRIG B, NTP and PTP time synchronization protocols
- Supports PQDIF and/or COMTRADE power quality data formats
- Optional - digital and analog inputs for capturing equipment status information
- Optional - digital and analog outputs for control applications
- Optional - support for custom programming to create additional applications

Example of a harmonics compliance report

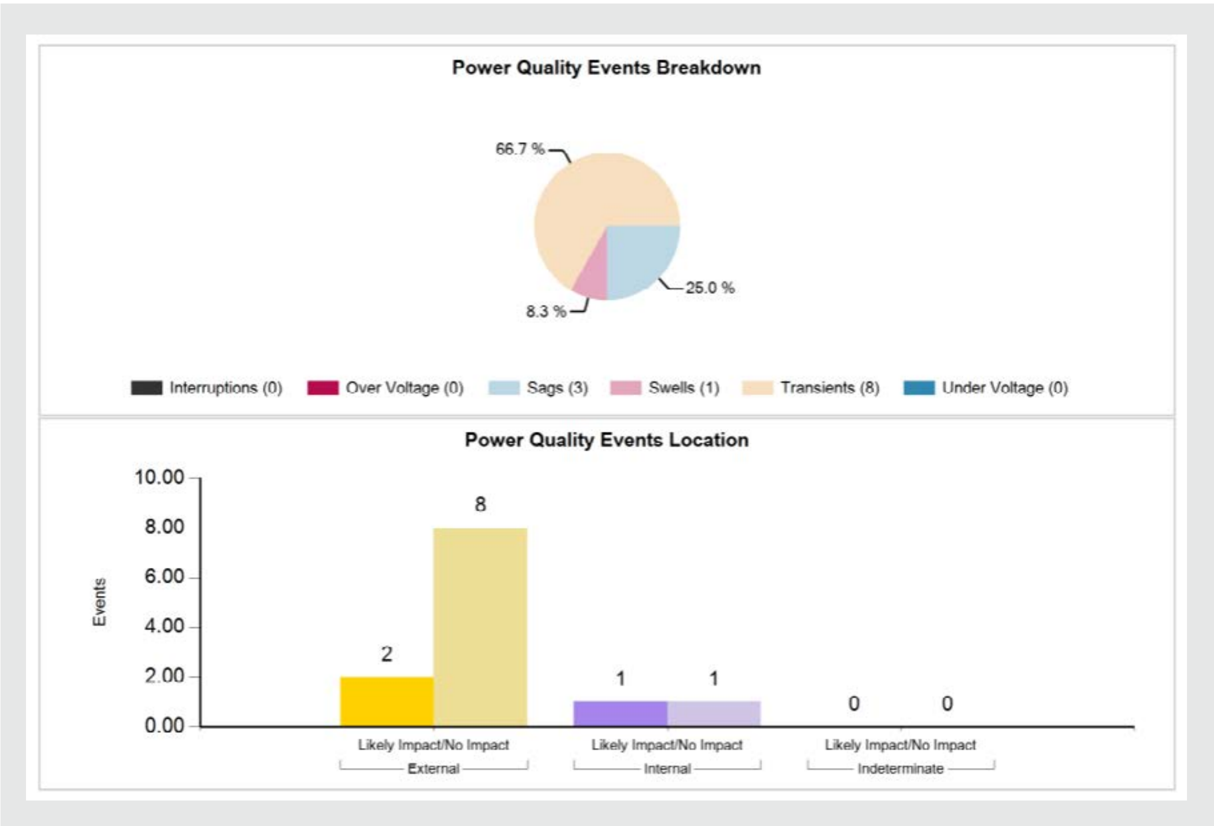
Very Short Time Current Distortion Compliance - 99th Percentile						
Isc/IL = 10	Individual Harmonic Order (Odd)					TDD (%)
Ratio Window Limit (0 - 20)	<11	11≤h<17	17≤h<23	23≤h<35	35≤h	
IEEE 519 Limit (%)	8	4	3	1.2	0.6	10
Non-compliant 3-second Days	0					7
Total Days	31					
Compliance	PASS					FAIL

Very Short Time Current Distortion Compliance - Non Compliant Days								
	Individual Harmonics				TDD Limit - 10			
Date	Aggregate	I1	I2	I3	Aggregate	I1	I2	I3
7/10/2018	99.09%	99.08%	100.00%	99.98%	87.89%	100.00%	100.00%	87.81%
7/11/2018	99.80%	99.79%	100.00%	100.00%	93.48%	100.00%	100.00%	93.43%
7/12/2018	99.84%	99.84%	100.00%	100.00%	97.73%	100.00%	100.00%	97.71%
7/13/2018	99.55%	99.55%	99.99%	99.98%	95.16%	99.99%	100.00%	95.13%
7/22/2018	99.97%	99.97%	100.00%	100.00%	98.54%	100.00%	100.00%	98.53%
7/24/2018	99.99%	100.00%	100.00%	99.99%	93.90%	100.00%	100.00%	93.86%
7/26/2018	99.99%	100.00%	99.99%	100.00%	98.77%	100.00%	100.00%	98.77%

Power quality monitoring and power event analysis also require software designed specifically for collecting power quality information from advanced power meters and presenting it in specialized power event analysis graphical user interface. A well-implemented power quality monitoring and analysis application should be able to:

- Document the frequency and duration of specific types of power quality phenomenon according to power quality standards such as IEEE 1159
- Intelligently aggregate multiple, related events into a single “incident” for easier alarm management
- Plot voltage disturbances on a power quality curve, such as ITIC or SEMI F47
- Plot power quality and non-power quality events together on a timeline for event reconstruction analysis
- Declare the direction of travel and load impact caused by voltage sags and swells based on automated waveform analytics (no human intervention)
- Suggest probable cause for voltage transients, sags and swells based on automated waveform analytics (no human intervention)
- Automatically generate detailed EN50160 power supply compliance reports
- Automatically generate IEEE Standard 519-2022 harmonics compliance reports

Example of a power quality event report



Meter features – power availability applications reference table

Power Availability applications	Capacity Management	Backup Power	Power Quality
Per-phase and total power measurements (volts, amps, active power, reactive power, apparent power, power factor, THD)	●	●	●
High-accuracy, time-synchronizable onboard clock	±1 s	±10 ms	±1 ms
Timestamped alarms for power measurement events (configurable setpoints with hysteresis and time delays)	●	●	●
Onboard interval data logging for power measurements (configurable data recorders)	●	●	●
Optional digital and analog outputs (for control applications)	●	●	
Optional - Support for custom programming (to create additional functionality and applications)	●	●	●
High-speed triggers for alarms (½ cycle resolution or better)		●	●
High-speed data logging (½ cycle resolution or better)		●	●
Support for NTP and PTP time synchronization protocols		●	●
Digital and analog inputs (for capturing equipment status information)		●	●
At least Class 0.2 accuracy for Voltage & Current (as per IEC 61557-12)			●
IEC 61000 4-30 compliant			●
High sampling rate (at least 256 samples per cycle)			●
CT terminals for measuring power on the neutral conductor			●
High-speed voltage disturbance detection with waveform capture (on each phase and neutral circuit)			●
Disturbance Direction Detection (onboard analytics to determine direction of voltage transients, sags & swells)			●
Support for PQDiff and Comtrade power quality data formats			●

Capacity Management
- Power Monitoring
- Electrical Capacity Management

Backup Power
- Backup Power Monitoring & Testing

Power Quality
- Power Quality Monitoring & Analysis

Electrical metering system design

Specifying the best electricity metering infrastructure for buildings requires a good understanding of the electrical distribution system and the equipment that it serves. In general, the more complex an electrical distribution system is, the more comprehensive the metering specification will be. The electrical metering infrastructure needed for a large hospital, manufacturing plant, data center or industrial site can be quite advanced compared to the metering specification for a smaller building. However, the electrical metering infrastructure required for commercial, public, and institutional buildings also needs careful consideration. It is important to specify the right level of metering devices in key locations throughout the electrical distribution system to enable the desired sustainability and power availability applications.

Meter selection for key locations

When designing an electrical metering system, it is recommended **to specify different metering requirements for different locations in the electrical network**. If a problem occurs at an incoming transformer or main switchboard, power availability for the entire building is put at risk, whereas a service disruption in a final distribution panel only affects the loads served by that panel. Similarly, if a backup power system does not perform when it is called upon, it can put an organization into crisis mode and result in major operational disruption. In some cases, it could even pose a threat to human safety. In addition to the amount of load served by a given part of the electrical distribution system, one must also consider the type of load being served. Loads vary considerably in their size, location, and criticality.

Locations where meters are specified are called **metering points**. It is important to specify the right level of meter for each metering point in an electrical distribution system. To help guide and simplify the meter selection process, metering points can be classified into several broad categories, for which specific metering requirements can be applied:

- Service entrances
- Net energy metering points
- Backup / emergency power switchboards
- Renewables panelboards
- Secondary panelboards
- Critical loads
- Large loads
- Sensitive loads
- Common building loads
- Tenant loads
- EV panelboards

Service entrances

Power quality problems can have a major impact on operations and equipment resulting in major disruptions and financial losses.[14,15,16,17] It is important to monitor the quality of power that flows between the grid and a facility to ensure compliance to utility regulations, international power quality standards and to capture detailed information about power disturbances entering or leaving the facility.

Power quality information collected by power meters installed on utility service entrances at or near the point of common coupling (PoCC) is required for the following digital metering applications:

- Utility bill verification
- Power quality monitoring and power event analysis

Energy consumption data collected from these locations can also be used for sustainability applications such as:

- Compliance to energy codes & regulations, and green building programs
- Energy monitoring, performance, and verification
- Greenhouse gas and carbon reporting
- Energy cost allocation
- Sub-billing and tenant billing
- Electrical capacity management

For service entrance metering points, it is recommended to specify revenue-accurate, advanced power quality meters that can support the **power quality monitoring and power event analysis** application described earlier in this eBook.

Net energy metering

For buildings that have on-site power generation, it is important to track the amount of energy being produced locally compared to how much is being consumed from the utility. Energy data collected from these metering locations is needed to support sustainability applications such as:

- Compliance to energy codes & regulations, and green building programs
- Energy monitoring, performance, and verification
- Greenhouse gas and carbon reporting
- Energy cost allocation
- Sub-billing and tenant billing

Power usage data from these metering points is also used for electrical capacity management.

Renewables metering

It is becoming more popular for buildings to have renewable power generation capabilities in the form of solar panels and/or wind turbines. These alternative power generation systems utilize direct current (DC) circuits and batteries to produce a stable source of DC power that is connected to the main AC distribution network via inverters that convert the DC power into 50/60 Hz AC power at distribution voltage levels.

Due to the uncontrolled nature of solar and wind power generation and the injection of power through inverters into the main distribution network, it is recommended to install power meters to monitor the quality of incoming AC power provided by the inverters. Power measurements of particular importance for these metering points include: reactive power (kVAr), lagging and leading power factor, voltage imbalance and total current harmonic distortion (THDi).

[14] J. Manson and R. Targosz. 2008. **European Power Quality Survey Report, Leonardo Power Quality Initiative (LPQI)**
[15] Kundu Manus. **Power Quality (PQ) Concerns for Energy Efficient Economy 2014 Asia Power Quality**
[16] **2020 State of Commercial & Industrial Power Reliability Report** – S&C Electric Company in collaboration with Frost & Sullivan
[17] **Power Quality Reference Book**, October 2021 Edition. Electric Power Research Institute [EPRI]

Backup power system metering

It is recommended to have power quality meters installed to monitor the backup generators and the incoming circuits on all automatic transfer switches (ATSs). These metering locations are important for capturing high-resolution power measurement data and diagnostic information related to the operation of the generators and ATSs. It is recommended to use advanced, programmable power meters that have high sample rates, time synchronizable clocks, high speed event and measurement data capture and onboard digital & analog inputs for monitoring generator status points including the battery signature.

When configured correctly, advanced power meters should be able to capture the sequence of events: time at which the utility power was switched off, the generators were switched on, came online, started to supply to the load, and when the whole cycle was reversed (when the main utility power was restored). Information captured by these power meters can also be used to evaluate the generator's performance, help diagnose potential problems and determine if maintenance is required.

Historical power utilization data collected at these metering locations is also used to understand how much spare capacity exists in the system capacity and how loads can be re-distributed. For more information about power monitoring and electrical capacity management and backup power system performance monitoring and testing, please refer to the previous section in this eBook called **Digital metering applications**.

Critical loads

Loads that are essential to maintain operations or directly impact life-safety are typically classified as critical loads. What is considered a critical load will vary somewhat depending on the type of facility and the priorities of the business. For example, the critical load designations will be different for a hospital compared to a shopping mall.

From an electrical distribution design perspective, critical loads are served by circuits that are supported by an emergency backup power system, often comprised of uninterruptible power supplies (UPSs), automatic transfer switches (ATSs) and backup generators. The power metering requirements for an emergency backup power system are usually more advanced than the requirements for monitoring the critical loads themselves because circuits fed by UPSs are generally considered stable and reliable. As a result, the power metering requirements for metering points downstream from a UPS are usually quite basic. Since UPSs do not correct phase imbalance, it is advisable to specify a power metering device that measures voltage and current imbalance in addition to the basic power measurements offered by most energy and power metering devices.

Large loads and sensitive loads

Circuits that serve large, individual loads (>200 amps) need special consideration when specifying power monitoring devices because large loads can be the source of power quality disturbances. For example, large inductive loads such motors, fans, pumps, and compressors are often the cause of inrush current and voltage sags & swells when turned on or off. Some load types are very sensitive to power quality disturbances.

For example, voltage fluctuations and excessive harmonics can adversely affect imaging machines, precision tools, motors, computers, automation and control systems and any equipment containing digital electronics. Power quality disturbances can result in malfunction, data loss, data errors, circuit board failure, memory loss, power supply problems, software corruption, and nuisance breaker trips.

When specifying power monitoring devices for circuits serving large loads or power sensitive equipment, it is recommended to select a power quality meter that can support the **Power quality monitoring and power event analysis application** described earlier in this eBook.

Common building loads

Most building energy codes and building energy performance regulations require the installation of measurement devices to separately monitor the energy usage of common building load categories such as HVAC systems, interior lighting, exterior lighting, appliances, elevators & escalators and plug receptacles. For circuits serving common load categories, especially those described in local energy codes or regulations, it is recommended to specify electrical metering devices that support the **Compliance to energy codes, regulations, and green building programs** described in the **Digital metering applications** section of this eBook.

Tenant loads

Circuits that serve tenants (even shared circuits) should be metered to account for the electricity they consume – even if this is not mandated today by an authority. In regions where tenant metering is regulated, a compliant or certified meter must be used on these circuits. In places where there are not any meter regulations pertaining to sub-billing or tenant billing, it is recommended to specify a power meter that meets the requirements described in the **Sub-billing and tenant billing metering requirements** section of this eBook.

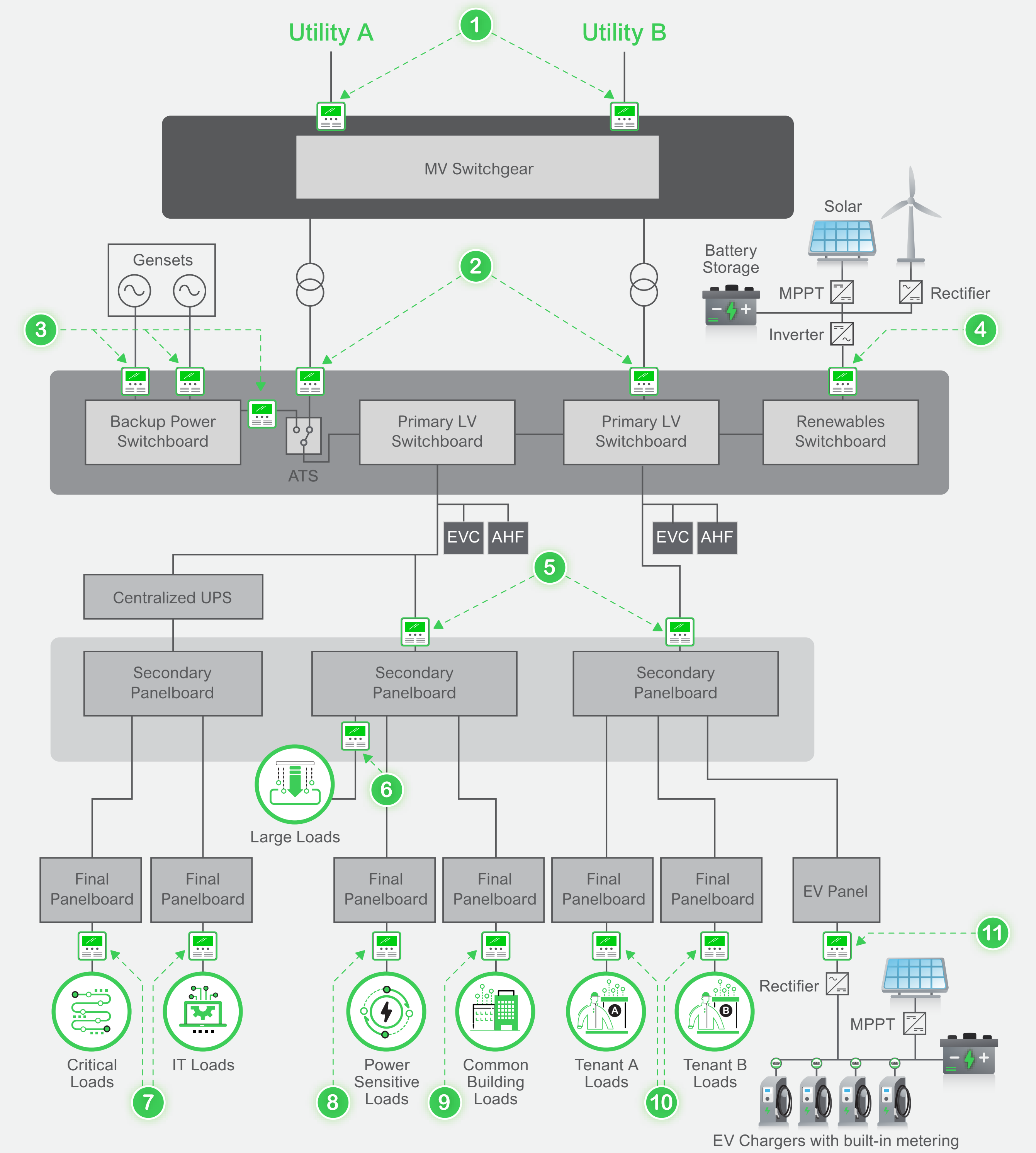
EV charging loads

Electric vehicle charging stations are being designed, built and added to sites at an unprecedented rate.[18] Most EV chargers are manufactured with built-in metering and communications capabilities to make electricity usage available for tracking and reporting purposes (i.e. ancillary metering). Electrical usage data collected from EV chargers can be used for Energy code & regulatory compliance, green buildings programs, energy monitoring and greenhouse gas & carbon reporting applications.

However, EV charging stations can adversely affect the power quality of the AC electrical distribution system serving them, so it is recommended to install a power quality meter in every AC subpanel that serves power to EV Chargers. Power measurements of particular importance for these metering points include: reactive power (kVAr), lagging and leading power factor, voltage imbalance and total current harmonic distortion (THDi).

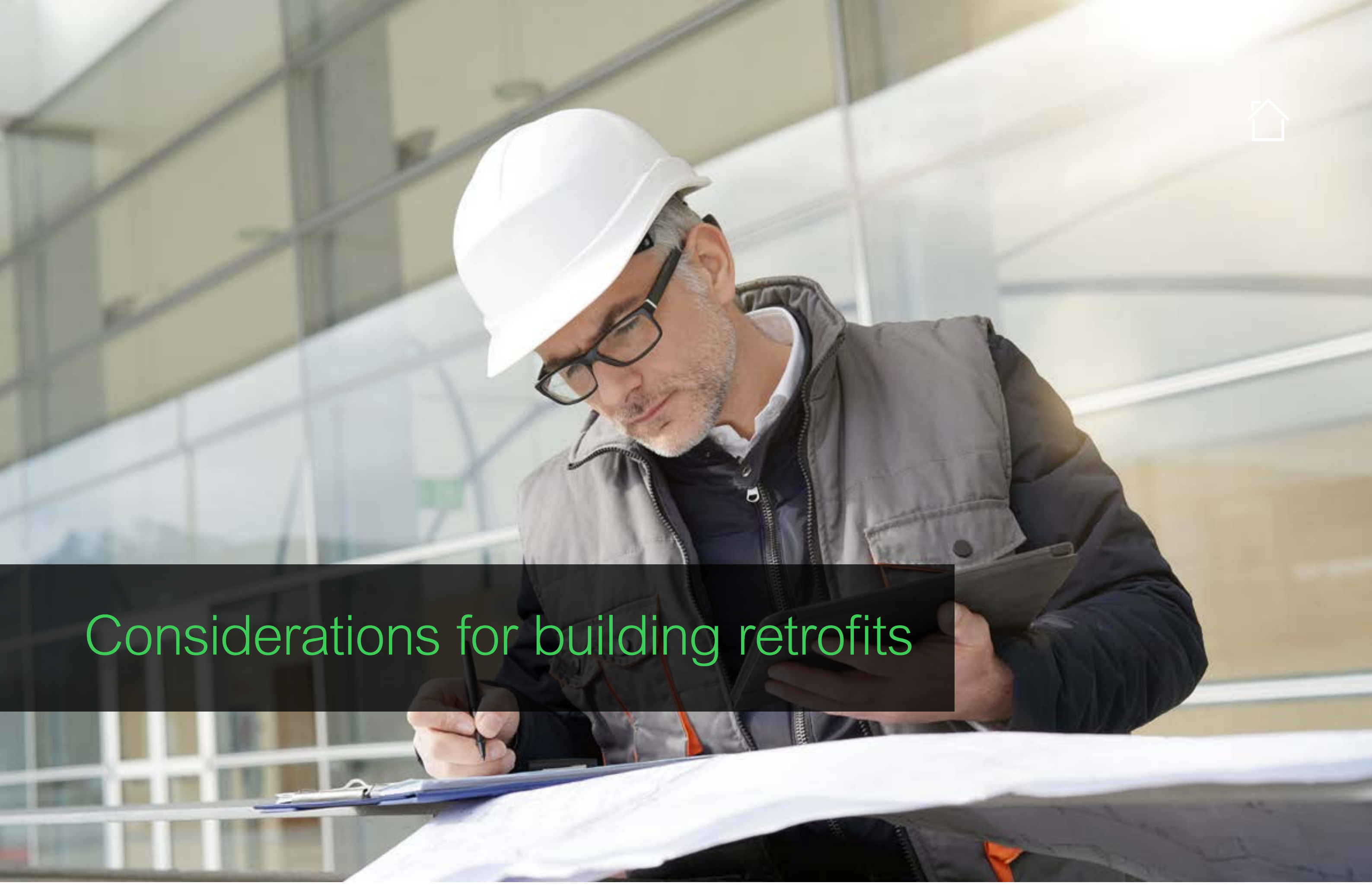
[18] **Electric Vehicle Charging Station Market Size Worth USD 111.90 Billion, Globally, by 2028 at 30.26% CAGR,** Fortune Business Insights, July 2022.

Metering point categories and system architecture



1. Service entrances
2. Net energy metering points
3. Backup power switchboards
4. Renewables switchboards
5. Secondary panelboards
6. Large loads
7. Critical loads
8. Sensitive loads
9. Common building loads
10. Tenant loads
11. EV panelboards

MV	Medium Voltage
LV	Low Voltage
ATS	Automatic Transfer Switch
EVC	Electronic VAR Compensator
AHF	Active Harmonic Filter
MPPT	Maximum Power Point Tracking
UPS	Uninterruptible Power Supply
EV	Electric Vehicle



Considerations for building retrofits

Across the developed world, cities are dominated by under-utilized and energy-inefficient buildings, despite many of them being less than 50 years old. Around 80% of the buildings we have today will exist in 2050, so it is essential for combating climate change that we retrofit them for energy efficiency.[19] One of the biggest considerations for a building retrofit is the electrical distribution system and having a comprehensive electrical metering infrastructure is a foundational requirement for all energy code-compliant, net-zero buildings.

Retrofitting a building for greater sustainability comes with a unique set of challenges. Existing equipment and systems must be evaluated thoroughly to determine what needs replacement or upgrading and what can be re-used or remain in service. Such decisions are extremely important as they will ultimately set the course for how resilient, efficient, and sustainable the building will be over the next phase of its life.

80%

of the buildings we have today will exist in 2050.

World Economic Forum

[19] To create net-zero cities, we need to look hard at our older buildings, World Economic Forum, 2022

The energy efficiency - electrification paradox

Building retrofits replace older, less efficient equipment with more energy efficient equipment, which means less energy used for the same amount of output. In addition, the devices that plug into electrical receptacles are also becoming more efficient which also contributes to less power being drawn. This means the existing circuits in the electrical distribution system may be larger than needed, representing excess unused capacity – which is not efficient, even though less energy is being used.

While existing electrical circuits may be larger than needed for newer equipment loads, the electrification of heating systems and the addition of EV charging stations is driving the need for more electrical capacity and new circuits to be installed to serve these new electric loads. Furthermore, building renovations for net zero typically include the installation of on-site, renewable power generation (solar, wind, geothermal) and energy storage systems (Battery storage, thermal storage, compressed air, flywheels), which have a major impact on the electrical design of a building.

76%

sites lack any or have only a partial monitoring system in place for operating their electrical network.

Schneider Electric EcoConsult audit results from over 400 sites between 2017 and 2022.

Power monitoring audits

Modernizing a building's electrical distribution system is an important step towards greater efficiency and reliability. The first step in an electrical system modernization project is an audit of the existing electrical infrastructure and its components. It is highly recommended to include a power monitoring audit as part of an electrical system audit. A power monitoring audit focuses on the digital devices and software used for energy monitoring and power measurement data acquisition and is comprised of four steps:

1. Discovery and fact-finding
2. Site assessment
3. Meter selection and system design
4. Final report and recommendations

1. Discovery and fact finding

A power monitoring audit consultation starts with a review of the business goals and the desired outcomes of a power monitoring system retrofit. Digital metering applications are discussed and mapped to business objectives and information about the existing power distribution network, electrical metering infrastructure and related communication networks is collected. Since load categories play such a big role in meter selection is important to capture information about the different types of loads (critical loads, large loads, electro-sensitive loads, tenant loads, common building loads, etc.) served by the electrical system. If a single-line diagram (SLD) is available, it can be extremely useful for locating existing metering devices and identifying important locations that lack metering.

During this discovery step, it is also important to gather information about the software system(s) that currently use metering data, especially any software platform(s) that retrieves power measurement and energy usage data directly from the existing metering devices (e.g. EMS, EPMS or BMS software). Key software attributes include:

- Software manufacturer, name/model and current version
- Type/category of software
- High level description – Brochure and user manual
- Original installation date and upgrade/patch history
- End of manufacturer support for the software
- Overview of the software system architecture
- Location(s) of installed components (application servers, database servers, reporting servers, client workstations, etc.)
- Number and type of metering devices polled by the software

89%

sites lack any or have only a partial mapping of their electrical installation (single-line diagram)

Schneider Electric EcoConsult audit results from over 400 sites between 2017 and 2022.

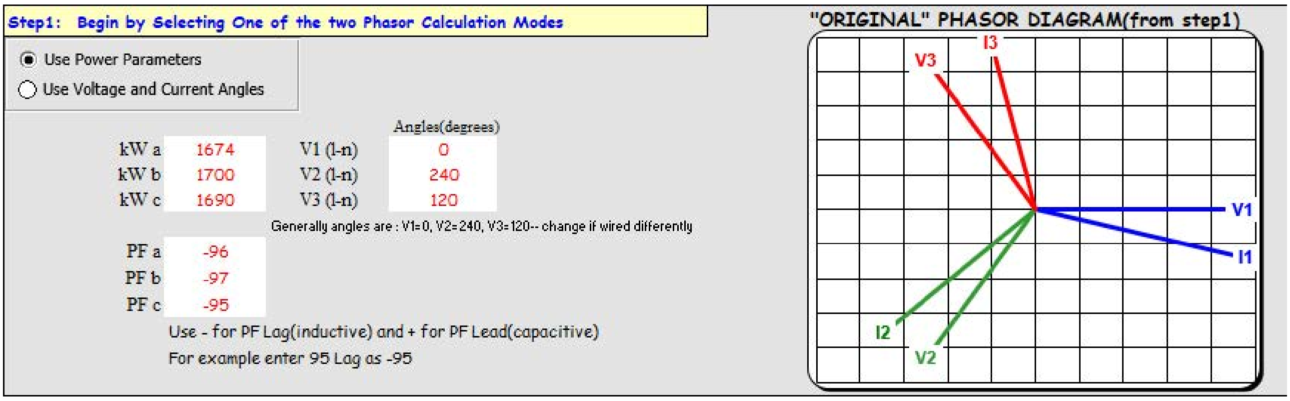
2. Site assessment

The next step in a power monitoring audit is an on-site walkthrough to assess and document the existing metering device infrastructure and its associated communication architecture. The audit should capture as much detail per device as possible, including:

- Picture of device – in situ is preferred
- Location of device – panel, cubicle, room number
- Device type and manufacturer
- Device name and nameplate info – model, serial #
- Firmware version
- End of support date from manufacturer
- Date of installation – age of device
- Device installation/mounting description
- Amperage of the circuit
- Wiring configuration
- Picture of CT shorting blocks and voltage disconnect
- Location of CT's and CT ratio
- Physical communication wiring details
- System connection info – software polling the device
- Communication options supported by the device
- Meter communication settings documented
- Basic meter readings captured
- Per phase voltage (V), active power (kW), power factor
- Potential meter wiring issues noted
- Potential meter configuration problems noted

During the walkthrough, it is highly advisable to **check that each metering device is wired and set up correctly and producing correct meter readings**. A Meter Wiring Troubleshooting Tool can be used to confirm correct wiring and can deduce what the wiring problem is if incorrect readings are being produced.

Meter Wiring Diagnostic Tool



* Click **here** to download the **Meter Wiring Diagnostic Tool**.

Correctly wired power meters can still produce incorrect readings if they are not configured properly, especially dedicated 3-phase power meters. A metering device audit should also capture the configuration settings of the meter that relate to how the device is wired and calculates its measurements. The most common meter setup mistake is not configuring the CT ratios. It is also recommended to document the communication settings in the meter and determine if the meter is connected to a communications network. Any problems related to wiring, meter setup or communication settings should be captured as part of the audit.

It is also important to identify all digital devices that have power measurement capabilities, including protection relays, circuit breaker trips, transfer switches, generator control units, uninterruptible power supplies, variable speed drives, power inverters and power quality correction equipment. Existing ancillary metering devices such as these may serve as suitable sources of basic power measurement and energy usage data and should not be overlooked..

A site assessment may also include an inspection of the software system that is currently collecting power measurement and energy usage data from existing metering devices (if the software system is accessible from the on-site location). The main purpose this is to verify the information collected during the initial discovery phase and gather as much additional information as possible about the capabilities of the software and the metering data that it is currently acquiring.

3. Meter selection and system design

After a detailed inventory of existing metering devices is captured, the next step is to design a metering system that enables the digital applications and business objectives identified in the discovery phase. When designing an electrical metering system as part of a building retrofit, there is an opportunity to reuse existing metering devices, but there are several things to consider before choosing to do so:

- Is the device in good working order?
- Is the device still supported by the manufacturer? How long will the device be supported by the manufacturer?
- What is the measurement accuracy of the device?
- Does the device support communications via an industry standard protocol such as Modbus or BACnet?
- What digital applications will the device be supporting?
- Does it provide the type of data needed to support all the desired applications?

After it has been determined which existing electrical metering devices will be used in the new metering system design, new metering devices will need to be specified for all of the remaining unmetered metering points. Please refer to the **Digital metering applications** and the **Electrical metering system design** sections in this eBook for more information about specifying metering requirements for various types of applications and where to install meters in your electrical distribution system.

Information about existing power/energy monitoring software collected at the initial discovery and during the site assessment should be reviewed to determine if the existing software is contemporary and capable of delivering the desired business outcomes described for the metering system retrofit. If the existing software meets these criteria and will be supported by the manufacturer for years into the future, it is likely best to continue to use it. In situations in which the existing software lacks fundamental capabilities, is older or future support is uncertain, then it may be simpler and more cost-effective to install new EPMS / EMS software rather than try to upgrade the existing software. In cases where there is no existing monitoring software, an EPMS / EMS software solution should be proposed.

4. Final report and recommendations

The last step of a Power Monitoring Audit is the presentation and handoff of the final report. A comprehensive Power Monitoring Audit report should contain:

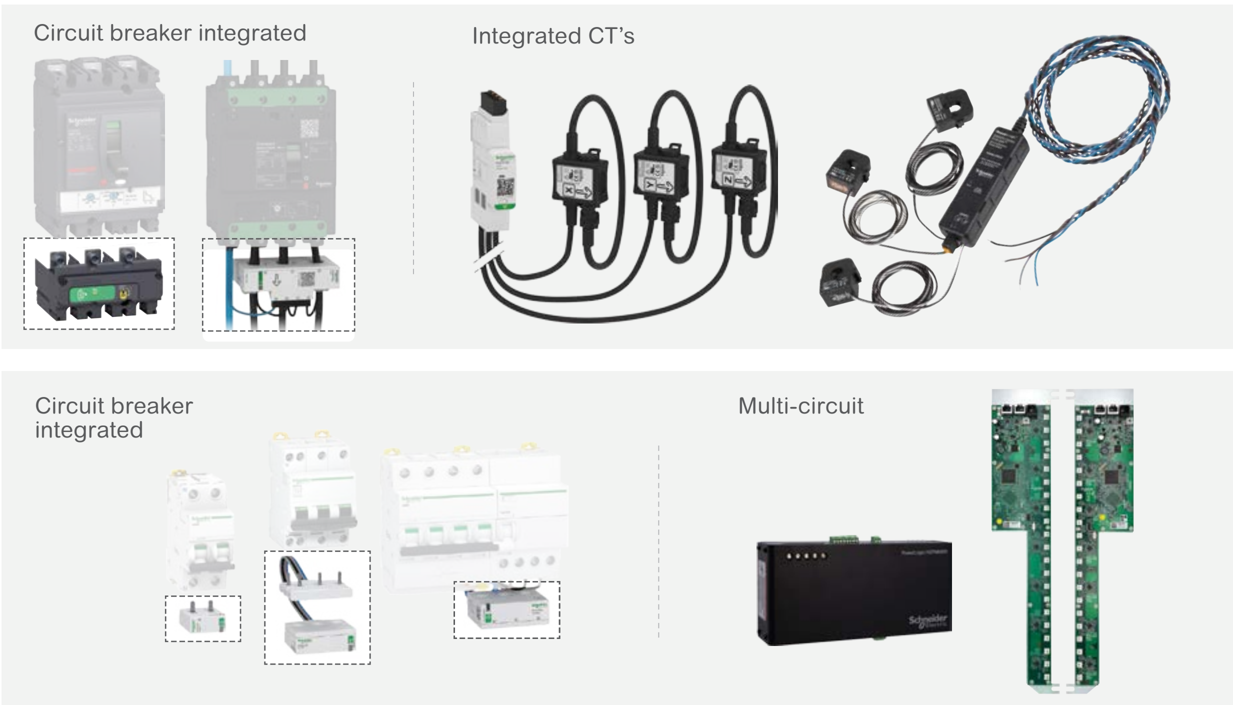
- Statement of business objectives, highlighting the digital metering applications that will be enabled if all recommendations in the report are followed
- Synopsis of existing power monitoring system capabilities and key findings
- Lifecycle analysis of existing power monitoring equipment and software
- Summary of wiring and meter configuration issues found
- List of noted discrepancies between SLD provided and field observations made during the site assessment
- Recommendations for metering device modernization and metering communication architectures
- Proposal for installation of new metering devices, including communication topology details
- Proposal for installation/upgrade/configuration of EPMS / EMS software to accomplish desired business objectives and identified digital metering applications
- Summary of the step-by-step implementation of the proposed power monitoring system, with options, based on business needs & budget

Electricity meters designed for retrofits

The cost to install and commission a power metering device is often greater than the cost of the meter itself. This is especially true for basic power meters that require control power and use external CTs. When selecting a power meter to retrofit into an existing electrical panel, it is recommended to choose a power meter that is designed for retrofit applications and has the following attributes:

- A small footprint – fits easily into any electrical panel
- Self-powered – no external power supply required
- Direct measurement (no CT's required) or integrated split-core/rope-style CT's
- Can be installed quickly and correctly the first time
- Simple to commission (meter configuration and communications)
- Certified compliant to international standards, especially IEC61557-12
- Mission profile and guaranteed calibration ≥ 10 years
- Complies with environmental regulations such as RoHS and REACH and transparent with environmental disclosures and end-of-life instructions

Retrofit metering devices



Metering data validation and integrity

An investment in electrical metering devices and a data acquisition system is only as good as the quality of data that is collected. Unfortunately, most power and energy management systems display incorrect values and have databases that contain bad data. **In fact, it is estimated that 98% of all energy monitoring systems have data integrity issues.**[20]

When you consider that power measurement data is used to evaluate electrical system performance, manage electrical capacity and diagnose electrical problems, it is important that the data acquired from all electricity metering devices is accurate, consistent and properly assigned. Incorrect meter data can misinform operators and facility management teams, causing them to make wrong decisions that can lead to inefficiencies, equipment problems, unplanned downtime and exposure to unnecessary risk.

Electricity metering devices also provide interval energy usage data that is used to improve energy efficiency, lower carbon footprint and benchmark building performance. Metering data integrity problems can compromise energy management initiatives and mislead energy managers and decision makers resulting in setbacks and uncertainty.

98%

of energy monitoring systems have meter data quality issues.

Results from a Schneider Electric study of more than 500 energy and power monitoring systems

[20] Results from a Schneider Electric study of more than 500 energy and power monitoring systems - 2017

Leading causes of bad metering data

There are many things that can cause erroneous metering data and impact the integrity of a historical dataset but the most common causes are:

Incorrect meter and CT wiring

- Inverted CTs
- Incorrect phase and neutral wiring
- Incorrectly assigned phase labels

Data acquisition software configuration issues

- Network communication configuration problems
- Meter name/ID assigned to wrong device
- Misaligned logging intervals

Meter configuration mistakes

- Incorrect PT/CT ratios
- Incorrect nominal voltage
- Incorrect wiring declaration [delta vs wye]
- Incorrect demand interval declaration
- Inconsistent/illogical logging interval declaration

Identifying data quality issues

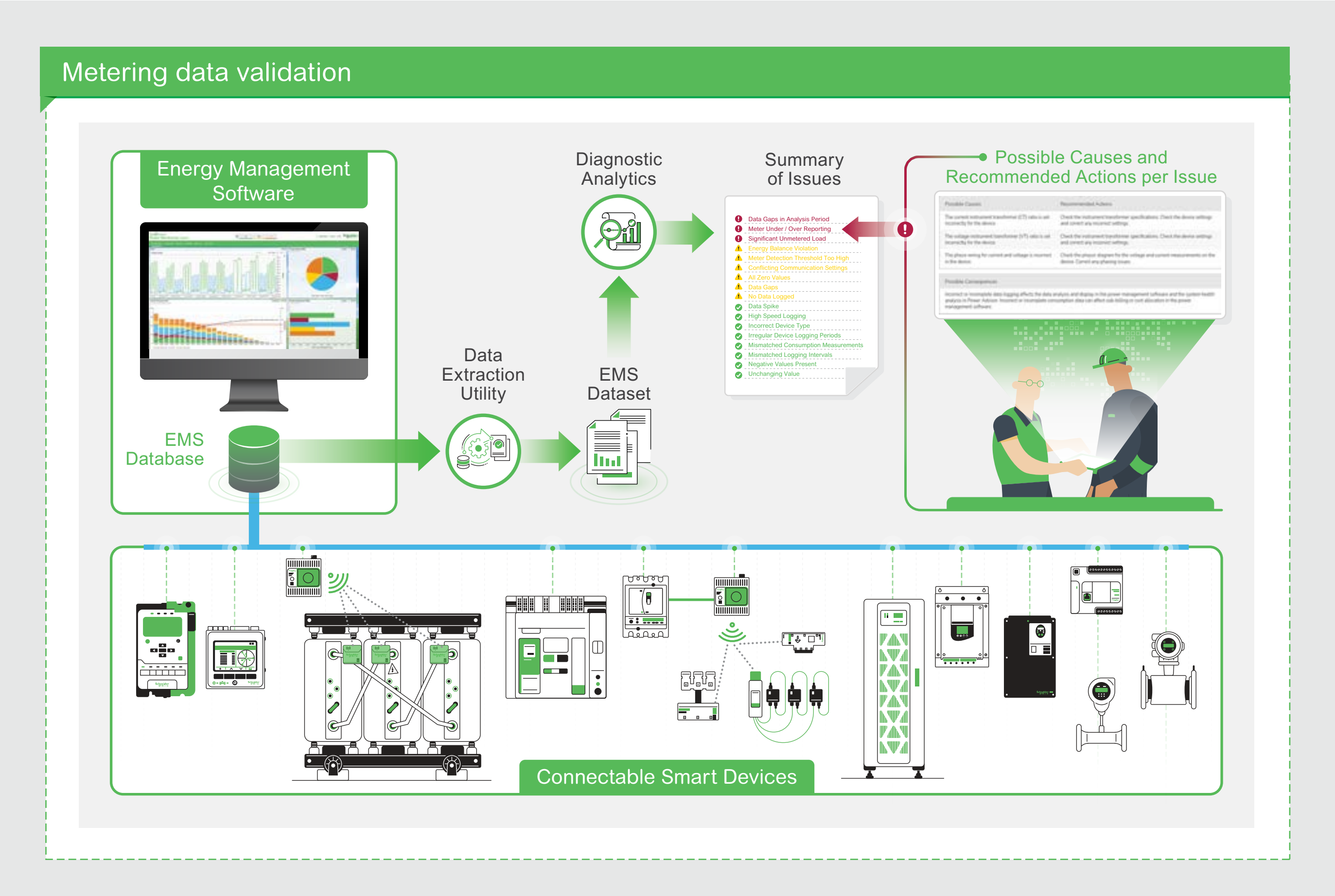
How does one know that their metering data is correct or incorrect? In some cases, it may be obvious and a search for the root cause is conducted and hopefully the problem is found and the issue gets resolved quickly without too impact on the organization. However, in most cases, data integrity issues go unnoticed and bad data can be collected and used for long periods of time. Identifying data quality issues starts with an understanding of what to look for. The most common electricity metering data integrity issues include:

- Data assigned to the wrong device or wrong device type
- More than one device with same communication address
- Some negative values or consistently negative values
- An energy balance violation (based on parent and submeter energy measurements)
- Irregular energy consumption (under or over reporting)
- Meter detection threshold too high
- Irregular device logging periods
- Mismatched logging intervals
- Frequent logging (<1 minute intervals)
- Unchanging values
- Data spike (unexpected extreme values)
- Data gaps
- No data – null values
- All zero values

Solving the data integrity challenge with automated data validation

Presenting correct information and creating high-quality, historical datasets for power measurements and energy usage requires that all electrical metering devices are correctly wired & configured and that any software that interrogates the metering devices is also correctly configured. There is so much opportunity for an error to occur, it is highly unlikely that all these things will be done correctly the first time. This is why metering dataset validation is so important. However, knowing what to check and finding a way to check everything in a consistent and efficient manner, is a big challenge.

Manual data verification methods are time-consuming and error-prone. Fortunately, specialized software tools are available that can identify anomalies in metering datasets and suggest probable causes for the issues detected. It is highly recommended to implement a proactive approach to meter dataset validation using software and data analytics as a way to detect meter installation problems, and configuration issues and to ensure a high-quality dataset that is trustworthy and known to be correct.



Does verifying data quality have an ROI?

Over time, maintenance, modernization and expansions can introduce changes to equipment and configuration settings that adversely affect how metering data is generated and captured by EPMS / EMS software leading to a loss of data integrity. **Storing and distributing bad energy usage data can lead to misinterpretation, poor decision making, inefficiencies and wasted opportunities.**

Looking ahead

Electricity will play a much larger role in energy consumption in the future. 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.[21] As a result, engineering, design, & consulting firms are under increasing pressure to keep up with the latest smart electrical distribution architectures and power management technologies to deliver solutions that are compliant to todays' energy codes & regulations and meet the sustainability and carbon reduction goals of their clients. To be more successful, many firms are moving away from the traditional design-build process in favor of a more collaborative approach that embraces digitalization across related domains such as microgrid, power and energy management, and building management.[22] But in the face of such a rapidly changing technology landscape, it can be very difficult to know which technologies will persist and continue to provide value and which ones will soon become obsolete.

One of the best ways to ensure that a building is future-proof and flexible enough to take advantage of emerging technologies and services over its lifecycle is to fully digitalize its infrastructure and subsystems. This is especially true for electrical distribution systems because buildings of the future will be all electric with advanced power automation and energy management capabilities. A comprehensive submetering infrastructure must be in place to collect the real-time data necessary to enable advanced energy & power management applications. A fully digitalized electrical infrastructure is essential for enabling new, innovative applications, artificial intelligence, and digital services that do not exist today.

[21] Net-zero Carbon Cities: An Integrated Approach, World Economic Forum Report, January 2021.

[22] Designing for Facility Management 2.0: Changing how digital systems are specified to achieve smart building outcomes - Schneider Electric White Paper.

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