TECHNICAL FEATURE

Making the Case For Energy Metering

By Jim Plourde

What do a building's energy meters and an automobile's gages for speed, gas, oil, water and engine temperature have in common? They control nothing, but provide vital information to help a design engineer or operator maximize equipment operations.

Considering that energy costs represent a substantial portion of a building's operating budget, energy metering is necessary for managing energy consumption and costs. However, decisions about how many and what types of meters to install, and where to place them, are typically the domain of building design engineers.

All energy meters are not equal. Some are more sophisticated or "intelligent" than others. So, before making any decisions, engineers need to consider the role of energy metering in a building in light of these considerations:

- drivers of change;
- new vs. existing buildings; and
- goals of energy metering.

Drivers of Change

Energy prices tend to be volatile because they are based on supply and demand. Faced with rising prices, potential power brownouts, and the pressure to operate sustainable buildings, property owners and design engineers seek solutions to make the most of a building's energy use and budget.

At the same time, utility companies face the challenge of delivering sufficient energy to meet the demands of commercial properties. Government entities and utility companies often offer demand management opportunities and incentives (monetary or otherwise) to encourage effective use of energy in commercial buildings.

Building managers tend to pursue operational efficiency as a way to control energy consumption and costs. A byproduct of that approach is increased equipment reliability and longevity.

Optimized capacity planning for energy use offers another financial incentive. Capacity planning minimizes a design tendency to overbuild a building's mechanical system. Planning and the appropriate selection and placement of meters also promote personnel safety and minimize wasted time and effort. In the absence of appropriate energy meters, electricians have to manually look

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for tripped breakers, which expose them to arc flashes and other dangers. Meters also eliminate guesswork and save time by quickly pinpointing problems.

New vs. Existing Buildings

In a new building, design engineers have an opportunity to assess and specify the latest technologies. The staff is unencumbered by existing systems, but will need training on the new metering system.

New metering systems offer interoperability with other systems (such as energy management systems and building management systems) because engineers can design them to operate on platforms based on open standards. In addition, a new installation requires all new energy meters and possibly a separate network to process the data from these meters. As a result, the initial investment is greater than it would be to just add points to an existing system.

In an existing building, installing additional energy monitoring points may reduce overall costs because the equipment and network are already in place. However, equipment interoperability may become an issue when adding new points.

If an existing power monitoring system operates smoothly, it offers proven, known value. System expansion, however, may be complicated by the need to install system-compatible metering points. The use of noncompatible metering devices could lead to limited functionality (e.g., one brand of meter data management software may not be able to read the advanced registers in a different brand of meters).

Goals of Energy Metering

The rationale for installing energy meters is twofold: to control energy consumption/costs and to improve equipment energy use/reliability.

Controlling Energy Consumption and Costs

The savings realized by a metering program depend largely on the actions taken with the meter data. Estimates of energy savings have ranged from 1% to 20%, depending on the application of the metering systems (*Table 1*). The low-end savings of 0% to 2% is generally attributed to the “Hawthorne Effect,” a phenomenon whereby individual behaviors may be altered as a result of the individuals knowing that they are being studied. These savings quickly erode if the occupants realize that the meter data is not being used. To maximize energy savings, the meter data must be used to drive action.

Managing equipment based on real-time needs helps maximize the efficiency of building equipment and systems. For instance, turning off certain equipment after-hours will conserve energy and eliminate unnecessary costs associated with operations and maintenance.

Time of use or load shifting impacts energy use by staggering when systems start and when they perform certain operations (e.g., precooling a building during off-peak periods). Allocating costs based on consumption—whether the information simply raises awareness among users rather than actually billing them for their energy use—can be an effective way to promote energy conservation and help control costs.

Intelligent metering systems enable building owners to take advantage of demand management opportunities (e.g., utility company incentives to prechill a building or reduce energy consumption during peak periods) and to calculate needs based on historical records. They also validate energy conservation measures, enabling design engineers or building engineers to build a business case for purchasing new equipment or modifying an existing system.

Justifying the Cost of a Metering System

Not every facility warrants a metering system, and a simple way to cost-justify a utility meter was developed by the U.S. Department of Energy:

$$\frac{\left[\left(\dfrac{\text{Installed Cost}}{\text{Desired Simple Payback}}\right)+\text{Annual Cost}\right]}{\%\ \text{Annual Savings}}=\begin{array}{c}\text{Minimum Annual}\\ \text{Electric Bill}\end{array}$$

where

Installed Cost is the total cost to purchase, install and commission the meter.

Desired Simple Payback represents the number of years it will take the metering system to produce the cost savings equal to the installed cost. In the federal sector, the simple payback period should be 10 years or less.

Annual Cost is the total annual cost of the fees and expenses to cover communications, data collection and storage, data analysis, as well as meter operations and maintenance.

Percent Annual Savings is the estimated cost savings benefits to be realized from the productive use of the metered data (typically a minimum of 2%).

Improving Equipment Use and Reliability

Modern mechanical systems (e.g., chillers, compressors, VFDs, lighting ballasts) generally rely on advanced electronics for their control and operation. Because electronics are sensitive to power quality, mechanical systems may be adversely affected by over- and under-voltage, surges, spikes, transients and harmonics. Advanced submetering systems detect these damaging, power quality events and alert system operators so they can take remedial action before damage occurs.

Building and design engineers can improve equipment use by accurately measuring how much equipment and electrical capacity are required for optimum building operation. “Right sizing” mechanical and electrical systems enables engineers to not only improve system efficiencies, but also to better manage utility costs and possibly delay capital expenditures for replacement or expansion systems until absolutely necessary.

Specifying the Right Meter

Energy travels from a utility company’s power supply into a facility’s electrical distribution (ED) system, with the energy handoff occurring at a “service entrance.” In a large commercial building, the service entrance typically sends the high-voltage energy (e.g., 13.3 kV or 21 kV) to a substation, which "steps down" the voltage to a more usable level before feeding it into a facility's subsidiary circuits (*Figure 1*).

Action	Observed Savings
Installation of Meters	**0% to 2%** The Hawthorne Effect
Bill Allocation Only	**2.5% to 5%** Improved Occupant Awareness
Building Tune-Up And Load Management	**5% to 15%** Improved Awareness, Identification of Simple Operations and Maintenance Improvements and Managing Demand Loads Per Electric Rate Schedules
Ongoing Commissioning	**15% to 45%** Improved Awareness, Ongoing Identification of Simple Operations and Maintenance Improvements and Continuing Management Attention

Table 1: Expected energy savings from utility metering.

Value of Intelligent Meters

More than just metering devices, intelligent meters can take measurements, store data and respond to new information. They serve on a building's front line, continuously gathering data and carrying out tasks. Some meters have advanced control functionality to accomplish the tasks of other intelligent devices (e.g., relays, power logic controllers [PLCs], and remote terminal units [RTUs]). Ultimately, these intelligent meters reduce the cost of materials, equipment and commissioning time required to build a power monitoring system.

For example, installing an intelligent "shadow meter" at the service entrance enables a building manager to validate the amount of energy the utility company actually hands off and also provides an opportunity to perform a power quality analysis. Validating the energy handoff minimizes the potential for utility bill discrepancies. Advanced metering capabilities perform tasks such as waveform analysis to ensure the quality of the power coming into the building.

In its simplest form, utility monitoring software processes the data collected by a meter and displays the information in a usable format. More advanced software solutions offer a combination of energy information and control capabilities that can simultaneously address diverse needs ranging from billing to load aggregation and cost allocation.

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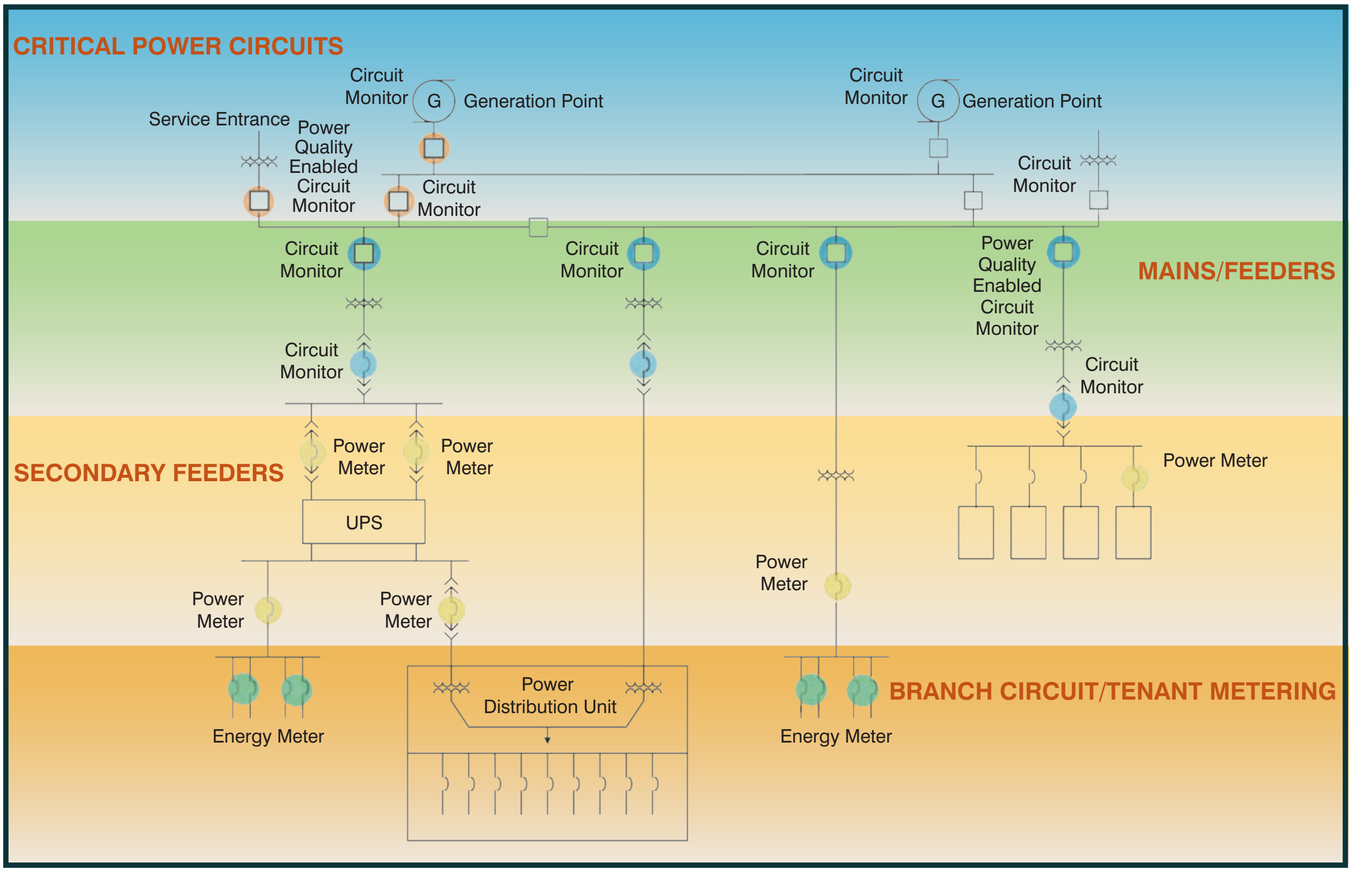

Figure 1: Typical metering points in a power distribution system.

Metering vs. Submetering

No hard and fast definitions are known for these terms. Submetering is typically thought of as an element of branch circuit-level monitoring through device monitoring—such as monitoring an individual piece of equipment or an end-user device.

The size of power monitoring systems will vary from one installation to another. Small systems often include metering of the service entrance(s) only, whereas campus environments often include additional monitoring points in every building, as well as individually submetered branches or devices. Ultimately, the size and complexity of a metering system will depend on its purpose.

For instance, submetering provides the ability to monitor individual tenants with regard to their energy consumption in order to bill them accordingly. Or, submetering may be used to determine how much energy individual chillers use, flagging unusual use that might be attributable to malfunctioning equipment. Submetering provides actionable information for decision-makers.

Why Data Quality Matters

Enterprise-level systems often fail as a result of poor data quality. Problems with data quality can then lead to incorrect information or conclusions—or even to premature system abandonment.

Data quality engines within a submetering system run data validation routines on a user-defined schedule. The system identifies potential data quality problems, as well as missing data, that can be corrected manually or automatically.

Manual correction involves addressing flagged data points and changing values through a data editing tool. Automatic data correction can take many forms, using data interpolation to correct for data jitter, duplicates, and nulls and voids. Whether imposed manually or automatically, all changes to the data in an energy monitoring system must have a complete audit trail to identify who made the changes-and when.

Weighing the Differences

More than one way exists to achieve the desired outcome: usable information for decision-makers. For example, a power utility metering system plays a vital role in a strategic energy action plan by ensuring that the initial energy and cost savings do not erode over time. Power meter installations, monitoring services, energy efficiency analysis and energy bill verification help achieve this goal.

Another effective alternative is an enterprise energy management (EEM) system, which provides energy-related business intelligence for stakeholders and offers one of the most effective ways to maintain benefits from a strategic energy action plan.

Essentially, an EEM system collects energy-relevant data pertaining to consumption of things such as water, compressed air, electricity and natural gas; it also considers other factors such as steam values, energy production information and outside air temperature. An EEM system collates all the information and then presents it to stakeholders in the form of actionable business intelligence in a customizable dashboard.

Getting Data From Here to There

Communication links transport data from the meter to other system software or devices. Software and meters generally communicate with each other through serial or Ethernet links.

Ultimately, energy meters send their data either directly to another system or through a database exchange to a meter data management/aggregation system or a building management system (BMS). Although most BMS tools allow for basic energy data trending and reporting, they lack the functionality required to reap the full benefit of having advanced, energy metering devices.

Data sent to a BMS enables a building manager to take advantage of applications ranging from demand control and load shedding or to a demand response program or an on-site power generator for supplemental energy during peak periods.

Data sent to an energy analytics tool offers building managers the ability to generate bills for tenant energy use, allocate costs to users or devices, analyze power quality (critical for tenants operating a computer center), and model "what-if" scenarios that might impact energy demands.

Interestingly, power quality analysis offers a very effective event direction/detection tool. For instance, it can pinpoint where an event occurred-down to the device or circuit level. This capability ultimately saves time and money to pinpoint and remedy a problem.

How to Leverage Data

Getting the most out of the data requires importing it into an advanced, energy analytics tool. This tool aggregates energy-related data from disparate systems and provides various levels of cost allocation, billing analysis, normalization (regression analysis and comparison of consumption in different regions), greenhouse gas (GHG) analysis and energy modeling.

Building managers can study the information an EEM system provides to discover new ways to better manage energy use or troubleshoot existing challenges. For example, a building manager or engineer can use an EEM system to model one utility rate against another, or to determine if one department's energy use is egregiously higher than that of others. More important, the information provides a starting point for investigating and addressing concerns.

Determining What Matters

Software needs to be scalable so that a system can start small and grow as needs change. Connectivity with other utility meters (water, gas, steam, etc.) is often provided through multipleprotocol communications ports and an ODBC-compliant database.

Here are some additional design considerations for new metering systems or additions to existing installations.

Setup Time

The time it takes to set up a system affects installation cost. Taking less time to configure the hardware and software lowers installation costs. For this reason, design engineers need to consider systems that do not require complex programming efforts before the system is even up and running.

The cost of the communications backbone can also contribute significantly to the total installed costs, depending on the equipment and labor involved. Therefore, it makes good business sense to select communications interfaces that adhere to industry standards and onboard designs to take advantage of existing networks without requiring additional hardware.

Onboard I/O

Analog and digital I/O ports allow building operators to bring a variety of data into a common system, simplifying data gathering efforts. I/O ports typically interface with relays, as well as transducers, for gas, steam, air and water metering.

Metering systems can use these inputs to count transducer pulses and breaker trips or to measure flow rates, rotations, fuel levels, oil pressures and transformer temperatures. The system can also use outputs for equipment control.

Multifunction Meters

To minimize the required number of individual pieces of metering equipment, the designer needs meters that serve multiple purposes. Many meters have several functions built into one unit, such as control, digital fault recording, load profiling, power quality, sequence-of-events recording, revenue metering, PLC, and RTU functionality.

Adaptability and Longevity

Adaptability is important because it affects the long-term cost of a system. An inflexible system may have to be replaced in a few years because its capabilities have become outdated. Instead, design engineers need to factor in adaptability to protect a building owner's original investment and to keep open options for adding modular components as needed. That advice also applies to meters, which should have flash firmware for simple, live upgrades.

Response Time and Throughput

Important factors for a power monitoring system to be successful include response time and throughput. The physical aspects of a metering network, along with the characteristics of the data being transmitted and the operating system, influence a monitoring system's response time and throughput.

Design engineers also need to consider the media mode that will be used, such as twisted pair, coaxial cable, fiber optic cable, radio, satellite, cellular, infrared, or a mix of media within the same system.

Maximizing throughput along noncontinuous channels like modems and cellular networks requires transmission of only useful information. For example, if all the design calls for is power quality information, then the system needs to send only the relevant parameters (often accomplished by configuring meters to "log by exception" and then transferring only the required data).

Final Thoughts

Meters provide information that can empower building owners and operators to make sound decisions about how their buildings use energy. Without the appropriate meters, they will not have the necessary tools to do more than just collect information. Therefore, it is important for design engineers to explain to owners, operators and tenants why the information is important and to give them one or more reasons for acting on the information. Submetering provides this capability by providing actionable information to decision-makers and users alike.

A BMS is not an energy analytics tool. It offers only simplistic trending and reporting capabilities. A rule of thumb is that if a power bill for an existing building reaches the $5,000 to $10,000 monthly range, it makes good business sense to install an energy analytics tool. For a new building, design engineers can compare energy use by similarly designed buildings in the area to determine whether installing an energy analytics tool makes good business sense.

Engineers may consider designing an energy analytics tool to tie into a BMS. However, the energy analytics tool offers better capabilities for delivering trending and reporting information than a BMS.

Metering platforms operate on wired or wireless architectures, depending on environmental factors. Tradeoffs exist for both architectures. Ultimately, it comes down to cost and speed. In older buildings it will probably cost more to run wiring between meters and into a network aggregator tool. In buildings under construction, open walls offer easy access for laying wireways and providing subsequent maintenance. However, new structures initially require installation of more meters.

In addition, a wired solution offers greater reliability (uptime) while probably incurring greater costs to install additional meters. A wireless solution offers greater savings on the initial installation while potentially increasing the risk for downtime if a network experiences outages.

The ideal power monitoring system addresses requirements in terms of application, installed cost, longevity, response time and throughput, reliability and integration. Ultimately, those responsible for designing and managing a building will need to consider design flexibility to accommodate multiple applications, including basic power metering, power quality monitoring, demand management, revenue metering, cost allocation and more.

When design engineers collaborate with those who will ultimately be responsible for managing the power metering system, the likelihood of achieving the "ideal solution" increases dramatically.●