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Features

In Brief

FEATURES

Making the Case for Submetering

When it comes to electrical submetering, information is not only power, it also is money. Electrical submetering can be a valuable tool for improving the management of electrical energy and for improving efficiency. There are at least six reasons why facilities should incorporate submetering into their energy management strategies, including verifying the accuracy of utility bills, allocating energy costs to specific departments or processes, troubleshooting electrical system problems, minimizing downtime, and preventing equipment failure.

Nothing can be managed until it is measured, and measuring use of electrical energy is crucial to bringing its cost under control. However, for many facilities, the amount of electricity used in a given period is only available from one source—the utility's electrical meter, located at the main electrical disconnect switch. It can be extremely difficult and tedious, and can even be futile, to use utility meter readings of consumption in kilowatt-hours (kWh)—often a very large single number—in allocating energy costs to specific activities or practices. Adding submetering to otherwise unmonitored electrical systems can decrease energy use by a few percentage points by increasing awareness, assigning accountability, and allowing follow-up.

Electrical submetering systems vary widely in design. For instance, such a system could consist of a handful of sophisticated meters located at main substation and distribution sites, or it could comprise many meters strategically located to provide information on every 50-kilowatt (kW) or larger load. In office buildings and commercial space, submetering may make economic sense only for tenant metering and bill allocations. For manufacturing and industrial sites, shared resources (such as chilled water and compressed air) are likely candidates for submetering—although motor, lighting, or process loads could be added, depending on the resolution required for full documentation and allocation of energy costs.

Six Reasons to Meter

It can be difficult to justify electrical submetering economically before the level of energy savings or improved productivity is known. Because electrical submetering often must compete for funding with projects that are commonly perceived as more directly relevant to a company's business (such as enhancing a manufacturing line or refurbishing outdated office space), finding a way to justify submetering can be a big hurdle for facility managers to overcome. However, there are six compelling reasons to install electrical submetering:

1. To verify the accuracy of utility bills.
2. To allocate energy costs to specific departments or processes.
3. To assign accountability for energy users.
4. To audit "before-and-after" energy usage for projects that were intended to improve efficiency.
5. To determine system efficiency and identify equipment and process problems.
6. To discover opportunities for potential energy-efficiency improvements (useful for planning future projects).

Reason 1: Verifying Utility Bills

Imagine paying every credit card bill you receive without even considering whether all the charges are really yours. Few bills are taken on faith as much as electric power bills. Month after month, energy bills roll in and are routinely paid by accounting personnel—who can only be expected to spot flagrant and obvious math errors.

Given the many thousands of dollars paid for energy every year by the owners and operators of most buildings and facilities, catching even a small accounting error could recoup the investment in electrical submetering in one swift stroke. (See sidebar, "Justifying the Cost of Submetering.") Even if no errors are caught by a submetering system, being able to independently verify an energy supplier's billing can increase the user's negotiating position and stature.

Reason 2: Allocating Energy Costs

One of the hallmarks of a good manager is knowing how much each of the many elements of a manufacturing process contributes to a product's final cost—whether that product is a manufactured item or heating and cooling in a building. Labor, raw materials, machinery costs, maintenance, and even environmental costs are regularly included in product cost calculations, but the cost of electric power often is not counted. It is rare for managers to know how many kilowatt-hours are consumed by a manufacturing process or by providing service to each tenant in an office building.

Some common methods for estimating energy allocation (based on square footage of floor space, number of workers or occupants, or the capacity of the electrical supply circuits) at least acknowledge the importance of assigning electric costs. However, these methods have the disadvantage of spreading energy savings from one area throughout an entire facility—and therefore provide no incentive for departments within a facility to reduce their own energy use. These methods also provide virtually no guidance for future energy-efficiency planning decisions.

Reason 3: Assigning Accountability for Energy Users

Unfortunately, energy efficiency is often low on the list of criteria by which managers are evaluated. In

most cases, however, this is the result of inadequate measurement. Monthly energy cost allocations to a department can provide a standard by which its manager's performance can be measured. Simply making energy efficiency a factor considered in managers' annual performance evaluations may shave a couple of percentage points from a company's overall energy expenses through such voluntary measures as turning lights, HVAC, and machinery off when they're not needed and fixing compressed-air leaks.

Justifying the Cost of Submetering

In many instances, an electrical submetering system can cost from a couple of thousand dollars (for simple monitoring of kilowatt-hours at a couple of locations) to tens of thousands of dollars (for automated reading of several parameters at many locations). This cost has been notoriously difficult to justify economically in retrofit applications, because it is very difficult to quantify economic benefits before the meters are installed. How can an expense today be justified economically by an uncertain return tomorrow?

Energy managers typically have high expectations regarding energy savings and improved operation due to electrical submetering. However, it is all but impossible to identify beforehand exactly where potential energy savings are hidden, and how much energy can be saved. Obviously, if an energy manager had that information, necessary changes would have been made a long time ago. Potential energy savings from submetering tend to fall into three general categories:

Savings from "just metering." Telling employees that electric energy use is being measured in greater detail can have the psychological effect of increasing awareness of energy use—thus causing people to notice energy waste (such as lights and computers that are left on, or thermostats that are set too high or low). The rationale is, "If someone's going to the trouble of measuring energy, it must be important." In practice, such savings may prove difficult to quantify because they can occur before baseline data is collected, and before cost allocation and auditing are implemented.

Savings from increased accountability. Additional energy savings can be expected if middle managers are held accountable for knowing—and controlling—energy costs. (See Reason 3.)

Savings from automation. The two points above demonstrate the benefits from "manual" voluntary energy savings that result from new information and incentives. Additional energy savings can be achieved by automating part of the submetering process, and then linking the functions of process controls to energy-related factors. For example, some manufacturing facilities operate several parallel manufacturing lines. At times of peak demand, the automated control system could shut down some of the lines or noncritical processes, or even warn operators of impending problems (such as the danger of incurring increased demand charges by inadvertently setting a new peak demand threshold).

There is always the chance that a submetering system could pay for itself very quickly—such as by catching a billing error or by avoiding the failure (and costly replacement or repair) of a crucial piece of equipment. However, since such events are difficult to predict, they should not be considered in the payback calculation.

Users should be aware that if a costly event does occur that could have been prevented (or mitigated) by the use of submeters, this unfortunate circumstance could be used as a convincing justification for a submetering expenditure.

For those situations or facilities where energy-savings estimates alone are insufficient to justify permanent electrical submetering, temporary or portable survey-type systems should be considered. Periodically spot-checking energy use for a department or tenant allows the discovery and correction of anomalies (albeit not as quickly as when permanent meters are monitored continually). Survey meters can be configured in portable test stands that are moved from location to location, allowing many facilities to be checked with one investment in equipment.

One way to compare the relative energy-efficiency performance of departments is to analyze energy use per unit manufactured, or per tenant occupant. Such methods allow continuous improvement of energy efficiency to be documented—similar to how other systems document continuous improvement in productivity, quality, or customer or client satisfaction. Other useful energy metrics can include kWh per part produced or energy cost per pound of product for industrial facilities and cost per square foot, per employee, per tenant, or per person-hour for commercial buildings.

Reason 4: Auditing Energy Use

Economic justification and approvals for energy-efficiency projects often face an uphill battle, because such projects often aren't viewed as central to a company's business. They typically focus on cutting costs rather than on increasing production. It is also true that future energy cost savings can be difficult to quantify, making many managers reluctant to invest in submetering. To establish supporting evidence that would help justify future energy efficiency projects, two types of supporting data should be gathered from projects currently in the works. Submetering can supply both: Before a project, gather measured data that quantifies the energy savings opportunity, and after a project, gather measured data that verifies the expected rate of savings.

Even if no energy-efficiency projects are currently underway, it is useful to gather baseline information about a facility's energy use (see Reason 6). It is helpful (and interesting) to notify employees and occupants when energy benchmarking is initiated. Accurately measuring energy costs can show that decisions made by production or building management staff—not just those of the energy manager—play a significant role in the overall cost of energy for a facility.

Reason 5: Determining System Efficiency and Identifying Problems

Is the energy efficiency of installed office or manufacturing equipment acceptable? The only way to know is to measure. By strategically positioning electrical submeters on circuits that feed key pieces of equipment, energy managers can develop powerful energy metrics (statistics or benchmark values) for evaluating the performance of existing equipment as well as for use in choosing new machinery.

In most facilities, the only metrics available for evaluating the efficiency of a device or process are the original design specifications and the vendor's claims—both of unknown accuracy. Even when metrics for energy use do exist, they are often in a form that is not intuitive (such as kWh per month or year). A better approach is to use submetering to develop energy-use metrics that are meaningful.

In addition, monitoring the energy consumption of equipment and processes can provide useful—and often critical—early warning of undesirable changes. For example, what if an adjustable-speed drive were manually set to operate at full speed and then inadvertently left that way? It would be all but impossible to discover that problem among the thousands of kWh reported on a facilitywide electric bill. However, periodic checking of a local electrical submeter could show that although production in the area did not increase, energy consumption did—thereby alerting operators to look for a cause.

In another example, what if the thermostat on a 50-kW electric space heater malfunctions, causing the heater to operate continuously? Many installations would discover this problem only in the unlikely event that an especially observant operator or maintenance person notices the unit running unnecessarily. Submetering can help in early

identification of many types of equipment or process problems that are sources of energy loss, including:

- Plugged heat-exchanger coils in chiller plants;
- Clogging inlet filters on air compressors;
- Wearing of load bearings or gear boxes, or loss of lubricant in motors; and
- Control failures that cause equipment to run continuously or at inappropriate times.

Reason 6: Discovering Future Energy Savings Opportunities

Electrical submetering can help track down energy savings opportunities by answering the following two questions.

Who is using the most energy, and how are they using it? Electrical submetering can identify the key users (departments or processes) of electrical power in a building or facility, and provide crucial information about the profile of those loads and their contribution to peak demand penalties. This information can allow an energy manager to focus early on the biggest savings opportunities in each building or process area, greatly improving the effectiveness of subsequent measures.

Energy savings compared to what? An ongoing benefit of electrical submetering is sound, detailed documentation of a building's or facility's historical energy-use patterns. Far too many cost reduction projects have failed to produce expected levels of savings because initial estimates were based on spotty measurements that failed to take into account periodic, seasonal, or unusual factors. Having a solid database of previous energy use to draw upon and compare against can increase confidence in projections of energy savings.

Turn Energy Management over to Neural Networks and Intelligent Agents

It's like having the best and brightest facility engineer sitting at a desk around the clock, 24/7, with a huge panel of knobs and gauges. He constantly tweaks every power-driven device that maintains building comfort. He works every moment to optimize the balance between least energy usage and greatest occupant comfort. He can do that simultaneously for dozens of buildings.

That always-on expert engineer is how users and advocates of WebGen Systems describe the "intelligent agents" of WebGen's load management system. WebGen can be used to integrate multiple building control systems, energy prices or tariffs, and weather inputs in real time. Modules of the system can be used to see usage trends, analyze performance of HVAC and other devices, generate cost reports and calculate differences against a baseline, and optimize participation in demand response (load reduction) programs.

Intelligent agents and neural networks are phrases that are being heard more often in energy management. Artificial neural networks (as opposed to neural networks in the human brain) have been a key descriptor of artificial intelligence since the late 1940s and were more aggressively developed in computer programming in the 1990s. At their most basic, neural networks are a connected group of simple processors, with each processor attending to a local task and local memory. Many definitions of neural networks include the capacity for the networked system to gain experiential knowledge, or "learn." Intelligent agents are computer programs that are constructed to act autonomously and take initiative on the basis of the neural network's experiential knowledge, preset goals, and priorities.

It's easiest to explain this computer technology by anthropomorphizing the software program and describing it as virtual human activity. Any monitored or measured activity, such as the cycling pattern of an air conditioner, operates on a pattern that is observable when the cycling is compared with outdoor and indoor temperatures. The neural network software learns these patterns and builds a rational analysis from them. From this analysis, it forecasts future "behavior" under particular temperature conditions. The longer the neural network observes the activity, the more information the network has and the more accurate the prediction can be.

Intelligent agents can go even further. A human manager can set desired goals, such as indoor temperature and humidity and lighting levels for certain spaces and certain times of day. Next, he can add an occupancy variable, so that temperature and lighting are to be at one setting if the space is empty and another setting if the space is occupied. Finally, the manager can set a goal of energy consumption efficiency or energy cost. Then he lets the intelligent agents of the software figure out how to reach and maintain those goals, even though they may seem impossible to balance.

The intelligent agent's first responses may seem clumsy and relatively ignorant, but taking advantage of neural-network learning, these agents soon calculate such things as fractional changes in setpoints of multiple devices that lead to a gradual combination of temperature, humidity, and lighting changes in dozens of buildings. The alternative, as may have been exercised by a human manager, would likely have been more dramatic temperature changes in fewer buildings. The intelligent agent can calculate many more variables than the human mind could track.

Nevertheless, WebGen maintains a human override control for occasions when conditions are observed or known to be different than they are measured. This manual control option addresses the most natural human concern of being controlled by a machine—as the computer Hal did in *2001: A Space Odyssey*—as well as allowing for the vagaries of human unpredictability and preferences.

Intelligent Agents at Work

Victor Atherton, assistant vice president for Facilities Management at the University of Miami, installed WebGen Systems more than a year ago. He's eager to use all of the functionality of the system, including the intelligent agents. Already he's counted savings in individual buildings ranging from 4 to 23 percent against the year before, using only the basic elements of WebGen as an energy information system.

But the two goals he has for the future will save even more. Atherton plans to integrate the campus building automation and control systems with the course schedule in real time, through WebGen. That way, if a class intended for a lecture hall is cancelled, the room won't be cooled and lighted in advance of the previously scheduled session. Currently, he's required to maintain comfort in all classrooms 8:00 a.m. to 10:00 p.m., whether the room is used or not. The integrated system could also automatically schedule work orders and could manage security access to rooms. Authorized personnel, such as instructors, could use the system to schedule classrooms or lab rooms differently. The intelligent agents would "know" when to start the air-handling unit to prepare the room for occupancy.

The other goal on Atherton's wish list is to shed load in a coordinated way, across multiple buildings. The campus has its own generating capacity, and Atherton wants to cooperate with the local utility. Currently, it's too difficult to list and

reprogram the building control systems to achieve a subtle 5 or 10 percent load reduction. With WebGen, the intelligent agents do the work.

Bank of America is a WebGen user, but its interest is also that of an investor in WebGen Systems. Since the bank installed the system in its California facilities, it has already seen that the payback required for such projects—a maximum of three years—will be met. The first savings were achieved when Bank of America was able to recognize patterns of use across multiple buildings. They were consistent . . . expensively so. Buildings were opened and chillers were started every Monday morning—all at the same time. Breaking down this consistency helped Bank of America lower energy costs without reducing occupant comfort.

More important, Bank of America was able to participate in California Energy Commission programs to reduce load on short notice. With one hour's notice, the corporation dropped 2 megawatts (MW) of its 9-MW load from a combined 78 locations. This coordinated action would not have been possible without the integrated WebGen system. Bank of America is now expanding its use of WebGen into other states where the corporation is responsible for energy costs in major facilities it occupies.

Intelligent Agents Save Money

For energy management, the newest computer-based building automation systems and energy information systems are capable of monitoring, calculating, and analyzing, and then comparing and forecasting. What will drive the use of intelligent agents in energy management is their solution to operations and maintenance staff shortages. Even with a platoon of staff, each human can monitor and make decisions on only a limited number of conditions. Programmed intelligent agents, however, offer parallel processing of scores of decision parameters, all in real time, to save money, save energy, and preserve comfort.

According to Dirk Mahling, chief technology officer of WebGen Systems, "The humans must set the goals; the intelligent agents just figure out how to get there."

IN BRIEF

DOE's LBNL Releases New Guidebook on How to Buy Green Power

In an effort to support the development of green power markets, the U.S. Department of Energy's (DOE's) Lawrence Berkeley National Laboratory (LBNL) has partnered its Federal Energy Management Program with the Center for Resource Solutions, the U.S. Environmental Protection Agency's Green Power Partnership, and the Sustainable Enterprise Program of the World Resources Institute to produce the *Guide to Purchasing Green Power*.

Although most organizations are relatively new to purchasing green power, research conducted by LBNL and others indicates a growing interest by governmental as well as public and private firms in diversifying their energy supply and, at the same time, reducing their environmental footprint. The *Guide* captures the advice, lessons learned, and expertise from a broad array of market participants—including facilities and energy managers, buyers, and researchers—to provide a set of operational guidelines for purchasing green power.

The *Guide* also answers questions on the benefits and costs of green power, how to communicate

those benefits and costs within an organization and to the public, options and steps for purchasing green power, ways of procuring renewable energy certificates, how to plan an on-site renewable generation project, and green power considerations for federal facilities.

A free copy of the report can be downloaded at:

- The Environmental Protection Agency's Green Power web site: www.epa.gov/greenpower/buygreenpower/guide.htm;
- The World Resources Institute's Green Power Group: www.thegreenpowergroup.org/publications.html; and
- The Center for Resource Solutions: www.resource-solutions.org.

Industrial Energy Management Resources Online

Industrial energy management professionals looking for quick, easy, and, in most cases, free resources online may want to visit the Alliance to Save Energy's (ASE) Industrial Energy Efficiency Clearinghouse. The Clearinghouse is an "introduction to the technologies, management strategies, training, and financing opportunities that are available to industrial energy users" and includes areas such as industrial financial resources, industrial energy-efficiency training, cutting-edge technologies, improvements to current technologies, and professional development resources. In addition, the site also includes information on how small to midsize manufacturers in the U.S. can qualify for free energy audits. Visit ASE's Industrial Energy Efficiency Clearinghouse at www.ase.org/section/topic/industry/clearinghouse.

Canadian-based manufacturers or U.S firms with Canadian operations may be interested in visiting The Canadian Industry Program for Energy Conservation (CIPEC) web site, which is sponsored by Natural Resources Canada (NRCan). The site provides information on technical guidebooks, how to apply for energy audit incentives, and how to get involved in energy benchmarking initiatives for specific manufacturing sectors. It also provides a fully searchable Energy Management Services Directory that includes consulting and engineering firms. Energy managers can also apply to become members of NRCan's Industrial Energy Innovators Program and receive access to a variety of energy-efficiency products and services. Visit NRCan's CIPEC web site at http://oee.nrcan.gc.ca/cipec/ieep/index.cfm?PrintView=N&Text=N.