Energy Program
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The Short Guide to Energy Submetering

As Resource Conservation Managers (RCM) and Energy Managers know, measuring and tracking the consumption of electricity, natural gas, and other resources is the key to reducing their consumption and associated costs. Utility bills based on utility meter readings are a consistent way to measure usage. They generally provide a total use every month, or longer in the case of some utilities, and measure to the building or campus level. Relying solely on utility meters however, may not provide enough detail to identify resource and cost savings opportunities.


Photo courtesy of Mark Jerome

This short article takes a look at submetering for energy management purposes. It discusses why and when to submeter, benefits and considerations of submetering, planning and installations, and a cursory look at some different types of equipment. How to interpret submeter data for energy management measures is not discussed. While the focus is on electrical submetering, there is some information on types of meters for natural gas, steam, water, and heated-water and chilled-water circulation.

It is expected that the information given here will give the reader a jumpstart to research and develop their own submetering plan.

Overview

Submeters are simply sensors that measure the flow of energy, fluid, or gas in more detail than a utility bill provides. Modern utility meters are often capable of capturing this greater detail, usually at 15-minute intervals, but few utilities offer this enhancement to their customers. This article focuses on submetering on the customer side of the meter, totally at the customer's option and expense, and under customer control.

Our Mission

To advance environmental and economic well-being by providing unmatched energy services, products, education and information based on world-class research.

About Us

Our staff of energy engineers, energy specialists, technical experts and software developers work out of Olympia, Washington. The WSU Energy Program is a self-supported department within the University.

Within WSU

We are part of the College of Agricultural, Human and Natural Resource Sciences. Our Director reports to the Dean of the College.

Contact

Karen Janowitz
RCM Program Coordinator
WSU Energy Program

Phone: 360-956-2000
Phone: 360-956-2096

email: *janowitzk@energy.wsu.edu*

Website: *www.energy.wsu.edu/PublicFacilitiesSupport/ResourceConservation.aspx*

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Equipment varies from mechanical submeters that measure peak kW at a point in time, to solid state advanced meters measuring energy, power quality, peak demand, and more over a period of time.

Installing submeters allows energy use to be measured in an individual building where there is only a campus-wide utility meter, for example. They can measure individual floors or tenant spaces within a building, individual building systems such as HVAC or lighting, or other systems and devices. Increased installations of heat pumps, heat pump water heaters, and other electric appliances, are spurring the need to monitor these end-use loads through submeters.

Using submeters to track energy use can lead to reduced energy and water consumption, create more efficient buildings with lower operating costs, increase building equipment longevity, improve occupant comfort, and resolve other building problems. In addition to optimizing building performance, submetering may be necessary to fulfill local and state requirements that have cropped up in recent years to reduce carbon footprints and progress toward low or zero net energy use – such as the City of Seattle commercial building benchmarking requirements.

More specifically, submetered data may be used to benchmark a building's energy use, measure energy use before and after implementing a project, identify energy improvement and retrofit opportunities through data variability and trends, create energy budgets and reports, perform measurement and verification for projects, calculate demand response or load shedding, find the most appropriate utility rate structure, verify utility bills, and much more. For agencies with cost-sharing or tenants, submetering can help create proper allocation of costs.

It is important to note that a submeter in itself does not reduce energy consumption. It is a tool that provides data that must be analyzed and transformed into opportunities for action.

Submetering plans

Best practices/strategies

Before selecting and installing a submeter, it is important to have clear goals and create a submetering plan. Examples of goals include reducing the overall carbon footprint and energy consumption of a building, verifying savings from a lighting retrofit, isolating energy costs in a tenant-used space, and troubleshooting HVAC system problems. These goals help determine the output data needed, and type and cost of submeter and other devices.

As a submeter plan is developed, consider these best practices and strategies:

- Do not underestimate the tendency to expand the scope of the submeter plan. More features or more submeters may not fulfill objectives and may be more expensive.
- Consider how to maximize value while minimizing cost.
- Have an appropriate and realistic scope for the building, issues to be addressed, and budget.
- The following questions are important to answer:
  - Is the monitoring temporary or permanent?
  - How accurate does the collected information need to be?
  - Who will use the data and for what purpose?
- Which staff can meet the following needs (may be more than one person):
  - Metering and submetering equipment expertise,
  - Networking and communications skills,
  - Software commissioning and integration of databases into visualization and reporting tools.
- Ensure existence of appropriate as-built documents such as electrical panel schedules and line diagrams for installation.
- Understand communication methods that can transmit raw submeter data and create usable data.
- Compare installation costs with maintenance and operation costs. Some less expensive meters may have more disruptive installation requirements, and manual reading of meters adds labor.
- Consider the space where the submeter must physically fit. Make sure there is room for the submeter and any additional devices such as CTs.

Plan elements:
The following plan elements are essential for a successful submetering project:

- Establish goals and objectives, such as submetering for verification of projects, identifying failing equipment, or separating campus buildings.
- Ensure that resources such as appropriate staff and budget are available.
- Identify buildings, sub-buildings, and end uses to submeter using criteria such as size and function of building, future building plans, heating and cooling loads, etc.
- Prioritize buildings using criteria such as energy use intensity, future plans, or presence of a willing energy champion. (See section 3.3 in *Metering Best Practices: A Guide to Achieving Utility Resource Efficiency, https://www.energy.gov/sites/prod/files/2015/04/f21/mbpg2015.pdf*)
- Select the equipment that best supports your metering objectives. Compatibility with existing or planned Direct Digital Control (DDC) systems is important, and the inclusion of submetering may help justify a more comprehensive DDC upgrade or earlier replacement.
- When the submeter is installed, integrate it with the building system if necessary, calibrate it, and train users adequately.
- Collect and analyze submeter data.

If using a vendor to select, purchase, and install submeters, they should understand plan objectives and desired outcomes. Ask the vendor about open system integration, which eases interoperability of different devices and building systems. Consider getting multiple bids, giving the vendor a set budget amount and parameters for the work.

A submeter is functional only when the data it collects is communicated, analyzed, and acted upon. This can be to a local computer, to a building automation system or energy management system, or to the cloud via a web-based service which often can analyze the data. Transmission lines may be via WiFi, over the Ethernet, or existing electrical wires. The most important ingredient however, is a person responsible for reviewing the results, verifying opportunities, and recommending appropriate action.

Photo courtesy of Sensor Synergy

Costs
The cost to submeter entails more than just the device itself. Capital costs, labor, and recurring costs must be itemized and budgeted. In addition to the submeter, capital costs include ancillary devices – such as transformers, safety switches, and specific items for fluid meters, as well as communication devices such as modems, interfaces, and other hardware. Budgeting for miscellaneous supplies is also prudent. If appropriate computer hardware does not already exist at the agency, new equipment will most likely be needed.

Labor costs for installations will vary according to the type of submeter, where and how it will be installed, and if there are communication modules to connect. Allow enough time for operational testing and, most importantly, user training.

Recurring costs include communication and data fees, periodic calibration and testing, and maintenance and upkeep. Analyzing the data from the submeters may be an additional task for the RCM/Energy Manager and therefore also must be taken into account.

Submeters

Types of meters
Submeters vary in what they can measure and how often they make a measurement, as well as their size, type, level of accuracy, communication method, output rate, cost, reliability, and more.

Electric submeters have developed over the years from mechanical to electromechanical meters to advanced/solid state/digital meters. A simple, lower-cost mechanical submeter may still be a reasonable choice if an energy management system can only read pulse transmissions, or a simple connection to a computer is desired. The popularity and availability of advanced meters is rising, while the costs are beginning to fall. While these have superior data storage and communication, capital costs tend to be higher, although maintenance costs are on the low side. As electric utilities upgrade their meters, high quality mechanical meters that have been recalibrated and reset to zero are available for under $20. Many campuses have unused meter sockets on buildings such as portable classrooms, modular buildings and office trailers, etc. The hardware costs of basic submetering in these cases can be trivial.

Fluid metering technologies are used for natural gas, water, steam, and heated-water and chilled-water circulation, and most often use inline equipment for transmitting data. The most common types of submeters for all of these – with the exception of steam – fall into three categories: positive displacement meters, differential pressure meters, and velocity meters. Within these last two categories are many variations. Steam tends to be one of the more difficult fluids to meter, and uses differential pressure or velocity metering technologies. Water – including heated and chilled-water – is also able to be measured with ultrasonic velocity flow meters. This technology is the most expensive, but it is the easiest to install with the lowest installation and maintenance costs.

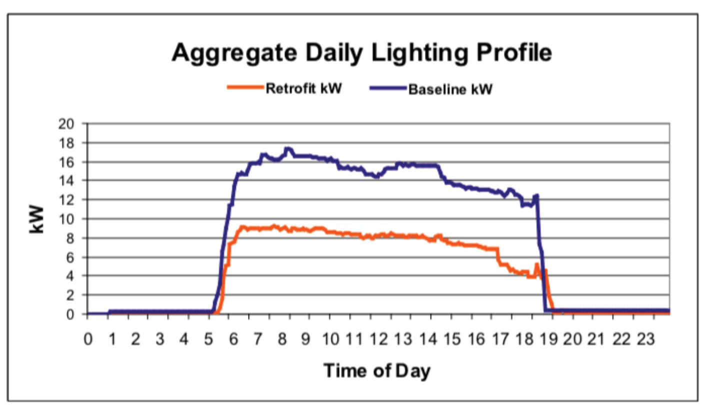
Measuring targets

Submeters can be categorized by what they track – a building, section of a building or series of devices, or one piece of equipment, which determines where they are installed. Submeters placed on a subpanel or particular electrical circuit may measure consumption in a building subsection like a floor, or equipment such as a group of chillers. These categories are listed below.

- ***Whole building energy use***
  Buildings that share a utility meter with other buildings are prime candidates for a whole building submeter. If aggregated with other campus buildings, it would not be possible to benchmark and account accurately for the individual building's energy.
- ***Sub-system, sub-panel, or branch circuit energy use***
  Specific areas of interest can be monitored by submeters placed within a subpanel, sub-distribution system, multiple points within a panel system, or at branches of a circuit. Examples of measured equipment includes groups of electrical plug loads or chillers, an individual boiler to separate it from a natural gas central plant, or cooling tower water or irrigation system to segregate it from a building level water metering system. This is also a way to measure energy use in a particular room, a floor, or section of a building.
- ***End-use energy***
  Submeters can also measure consumption used by specific equipment by being embedded with the device, which isolates the equipment for detailed study to identify inefficiency or validate savings estimate. These could be at each plug outlet or multiple outlets along a single distribution line, and can include monitoring chillers, boilers, lighting devices, plug loads and more. Meters that are visible at the point of use can be very valuable in occupant education and gaining support for conservation initiatives. A simple Kill-A-Watt plug load meter measuring a manager's computer, space heater, personal refrigerator or other loads could provide all the evidence needed for broad improvements.

Frequency of measurement

Another important level of categorizing submeters is by frequency of measurement, or time-interval. One-time or spot measurements measure instantaneous power, equipment performance, or energy load. The resource efficiency of a technology is measured rather



than energy conservation, which is the decrease of consumption over time. For example, a spot measurement can verify energy use of a new technology that replaced an older less efficient device. Spot measurement is used with a piece of equipment or a group of equipment.

Run-time, or interval measurements refer to resource use during hours of operations. Measurement is at the subsystem or subpanel level. Measuring power over the course of a day for a lighting system before and after an upgrade, for example, and plotting on a graph (see *Aggregate Daily Lighting Profile* on page 4), can help to verify the expected results of the project. This method can be used to measure energy to determine a billing rate for room usage.

Short-term monitoring is a combination of consumption measurement and run-time, or interval measurement. It produces time-series data to analyze consumption changes over a period of time due to changes in operations and maintenance (O&M) or occupant behavior, or to identify possible system problems. A classic example is to plot measurements of HVAC electric use over many weeks. If all operations of the building stay the same, the weekly profile is similar. Changes to the plot profile may indicate a problem – such as a failure of a system, a change in operation schedules, or even not adjusting to daylight savings time. Using this method at the system, sub-system, or building level can verify building performance, and create benchmarking and trending. Short-term monitoring can often be accomplished with portable, economical equipment such as Hobo Dataloggers, and spot measurements can often be accomplished by an RCM with a basic digital multimeter with a clamp-style current transducer.

At the system and building level, long-term or permanent monitoring is used to quantify magnitude and duration of resource use. This is the ideal way to measure persistent utility savings, performance verification and long-term trending – often at a longer time interval such as monthly. While this level is usually not sufficient to identify specific efficiency or operational issues, it can help focus the question on where to explore next.

Meter features to consider

When selecting submeters, consider the following features:

- Submeter communication – where does the submeter send data – a computer, energy management system, building automation system, or web-based service. The method must be compatible with your agency's infrastructure and building systems.
- Data output – pulse, serial, or Ethernet.
  - An older BAS or master controller may require pulse outputs and a pulse accumulator may also be needed.
  - Wireless serial communication is now fairly standard, such as Modbus RTU and BACnet MS/TP.
  - Ethernet connections often use Modbus TCP and BACnet IP.
- Rate of data collection – monthly usage total, or data collected at intervals such as one hour, 15 minutes or less.
- Accuracy – what level of accuracy is accepted for each device used, and ancillary equipment such as current transformers.
- Data storage – consider storing interval data locally in case of power outage, instead of the cloud.
- Data display – submeters with a local display tend to be more expensive.
- Measured data – power kW and kW demand (average power over a time interval).
- Standard protocols facilitate interoperability between different systems.
- More advanced meters usually have features of less advanced meters, but not always. Read the data sheet.

Barriers

A variety of factors must be considered in order to succeed with the goals of a submetering project. Many of these have been mentioned above. For example, the cost of submeters and their installation may be prohibitive for your agency, as well as the complexity involved in successfully transmitting raw data in a way that makes it easy to analyze. Make sure that the meter can communicate through the agency's firewalls, and if using wireless technology, there is no interference with other wireless office equipment, and it can move through floors and other areas. Be aware of security concerns. If data is being stored at a centralized data center offsite by the software vendor, it may be more susceptible to hacking, and also not available during a power outage. Data and device interoperability is important – systems sample data at different intervals, communicate with different protocols, and transmit data in a variety of formats.

Summary

Mechanical submeters and temporary dataloggers can provide the lowest cost solutions for some projects. While advanced submeters tend to be costly, technology advances and greater availability are bringing their cost down, making them a viable option. The appropriate submeter can be a cost-effective tool to reduce energy consumption and an agency's carbon footprint. It is hoped that this article has provided enough information to consider for additional research to bring successful submetering to your agency.

Resources:

Sustainable Facilities Tool, General Service Administration.
https://sftool.gov/explore/green-building/section/86/submetering/system-overview

Metering Best Practices: A Guide to Achieving Utility Resource Efficiency.
https://www.energy.gov/sites/prod/files/2015/04/f21/mbpg2015.pdf

Making the Case for Energy Metering and Monitoring at Industrial Facilities, 2011 ACEEE Summer Study on Energy Efficiency in Industry.
https://aceee.org/files/proceedings/2011/data/papers/0085-000064.pdf

New Buildings Institute offers FirstView software program that uses meter data to disaggregate loads into components.
https://newbuildings.org/resource/firstview/

The WSU Energy Program RCM Program supports the creation and successful implementation of RCM programs in the public sector by providing program and technical support. Public sector RCMs and energy managers in the State of Washington may join the RCM listserv to receive informative monthly RCM Newsletters.

Contact Karen Janowitz at ***janowitzk@energy.wsu.edu*** or visit ***http://www.energy.wsu.edu/PublicFacilitiesSupport/ResourceConservation.aspx***

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