DOE/EE-0312

Guidance for Electric Metering in Federal Buildings

February 3, 2006

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

FEMP
Federal Energy Management Program
www.eere.energy.gov/femp

Department of Energy
Washington, DC 20585

To Federal Agency Energy Managers:

The Energy Policy Act of 2005, Section 103, requires all Federal agencies to install metering and advanced metering at federal facilities, wherever found to be practicable, by October 31, 2012. This guidance document provides Federal energy program managers with information and recommendations for meeting the requirements of the law. The real key to effective use of metering is to combine meters with automated data collection, storage, and communication and analysis capabilities to operate our facilities more efficiently.

This legislation will have a significant positive impact on the abilities of Federal energy managers, facility managers, and building operators to improve the operating efficiencies of Federal buildings. DOE's Federal Energy Management Program (FEMP) plans to provide continuing support to Federal agencies in the development and implementation of their metering plans.

FEMP strives to enhance energy security, environmental stewardship and cost reduction within the Federal Government by advancing energy efficiency and water conservation; promoting the use of renewable energy, sustainable building design, and distributed energy resources; and improving utility management decisions at Federal facilities.

Rick Khan
Program Manager
Federal Energy Management Program
Energy Efficiency and Renewable Energy

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Executive Summary

The Energy Policy Act of 2005 (EPAct 2005), Section 103, requires all federal agencies to install metering and advanced metering where found to be cost-effective, according to guidelines developed by the Department of Energy (DOE), in consultation with a number of interest groups. DOE has met with representatives from the metering industry, the utility industry, energy services industry, energy efficiency industry, energy efficiency advocacy organizations, national laboratories, universities, and federal facility managers to develop the guidelines set forth in this document.

There were several areas in the language of Section 103 that required some level of clarification prior to finalizing these guidelines, as follows:

- DOE has determined that Section 103 pertains to ELECTRIC metering only.
- Section 103 applies to ALL electric metering, standard and advanced, at all federal buildings and subsystems, based on cost-effectiveness and practicability.
- The definition of "buildings," for the purposes of Section 103, should be considered the same as for annual energy reporting, and will also include industrial or process applications.
- "Maximum extent practicable" includes:
  - installation of metering and advanced metering wherever feasible;
  - the capability of providing useful data and information that leads to improved energy management practices or operations and maintenance improvements resulting in energy and/or energy-related cost savings;
  - the sensible application of metering technology; and
  - cost-effectiveness, which is based on a 10-year simple payback, assuming annual savings of at least 2%, or higher depending on the use of the metered data to implement energy savings and other cost savings measures.

Requirements for federal agencies:

- Agencies must submit their implementation plan by August 3, 2006. This is 6 months after DOE guidance is issued. Section 8 of these guidelines provides a template for agencies to use in developing their metering plans, and to be in compliance with the requirements of EPAct.
- Agencies are required to install standard or advanced meters at all federal buildings to the maximum extent practicable, by October 1, 2012.
- Agencies are required to report on their progress as part of their annual input to the DOE Report to Congress beginning with FY 2007. Progress will be measured based on the number of buildings metered and the percent of agency electricity consumption represented by those buildings. Starting with FY 2008, agencies will be required to report progress on both buildings with standard meters and buildings with advanced meters.

Acknowledgments

Thanks and credits to the Metering Guidance Drafting Committee:

Ab Ream, DOE Federal Energy Management Program

Jim Heller, Naval Facilities Engineering Services Center

Dave Hunt, Pacific Northwest National Laboratory

Greg Leifer, National Institute of Health

Glen Sittel, Naval Facilities Engineering Services Center

Greg Sullivan, Pacific Northwest National Laboratory

Carl Zeigler, Headquarters Marine Corps

In addition, Section 103 of EPAct required DOE to consult with "representatives from the metering industry, utility industry, energy services industry, energy efficiency industry, energy efficiency advocacy organizations, national laboratories, universities, and federal facility managers," in the development of these guidelines. On October 18, 2005, a meeting was held with representatives from the stakeholder groups to discuss the requirements of EPAct, present an initial outline of the guidance, and to get feedback from the groups. A draft document was then prepared and circulated for review and comment. A second meeting was held on December 14, 2005, to discuss the draft document and gain consensus. The following organizations were consulted during the development of the final guidance document:

- Association of Energy Engineers
- Defense Departments of the Navy, Army, Air Force and Marines
- Edison Electric Institute
- Federal Utility Partnership Working Group
- General Services Administration
- Lawrence Berkeley National Laboratory
- National Aeronautics and Space Administration
- National Institute of Health
- National Renewable Energy Laboratory
- Oak Ridge National Laboratory
- Pacific Northwest National Laboratory
- Texas A&M Engineering Experiment Station
- The Alliance to Save Energy
- The Demand Response and Metering (DRAM) Coalition
- U.S. Department of Energy
- U.S. Department of the Interior

Contents

Introduction

The Energy Policy Act of 2005 (EPAct 2005), Sec.103,[1] requires installation of meters and advanced electric meters on all federal buildings by the year 2012, according to guidelines set forth by the Department of Energy (DOE) in consultation with other federal agencies and stakeholder groups. This document provides that guidance, which should be applied to each agency's approach to metering as appropriate. It must be clearly understood that this document is not a federal policy for metering, but a set of guidelines for agencies to consider when setting their own individual policies.

This legislation will have a significant positive impact on the abilities of federal energy managers, facility managers, and building operators to improve the operating efficiencies of federal buildings. Considering that most federal buildings are currently not individually metered, it follows that measuring and managing energy usage at the building level is a difficult challenge. Moving from the current state to a situation where all buildings are being monitored on an hourly basis where practicable, and coupled with appropriate uses of the data coming from those meters, can only lead to increases in efficiency and reductions in energy expenditures for federal agencies.

The guidelines in this document address the requirements of EPAct 2005 by providing the following:

- Definitions
- Descriptions of metering approaches and some of the supporting technologies
- Discussion of methodologies to determine the costs and benefits of advanced metering
- Uses of advanced metering data and potential for electric savings
- Cost components of metering and advanced metering systems
- Methods for prioritizing buildings for metering applications
- Alternative methods of financing metering costs
- Template for agency metering plans
- DOE reporting requirements
- Reference materials and helpful web sites.

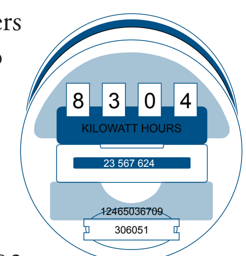
In addition to these guidelines, interested federal employees should refer to FEMP's Operations and Maintenance Web site[2] for further information on metering and training opportunities.

Federal agencies are required to submit their advanced metering plans to DOE/FEMP no later than 6 months after the issuance of this guidance. The due date for submittal of agency metering plans is projected to be no later than August 3, 2006.

Defining "Advanced Metering"

Meeting the 2012 metering goal will clearly be a challenge for the federal agencies and their facility managers. The first thing we need to do is gain a better understanding of what the legislation actually requires. In particular, we need to know what is meant by several terms used in EPAct Section 103. We offer these definitions:

Advanced meters. Advanced meters are those that have the capability to measure and record interval data (at least hourly for electricity), and communicate the data to a remote location in a format that can be easily integrated into an advanced metering system. EPAct Section 103 requires at least daily data collection capability.

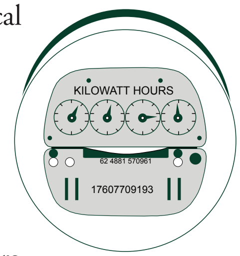


Advanced metering systems. A system that collects time-differentiated energy usage data from advanced meters via a network system on either an on-request or defined schedule basis. The system is capable of providing usage information on at least a daily basis and can support desired features and functionality related to energy use management, procurement, and operations.

[1] See Appendix B, Energy Policy Act of 2005 Federal Metering Requirements, for the full text of Section 103, or http://energy.senate.gov/public/_files/ConferenceReport0.pdf

[2] www.eere.energy.gov/femp/operations_maintenance/

Standard meters. Electromechanical or solid state meters that cumulatively measure, record and store aggregated kWh data that is periodically retrieved for use in customer billing or energy management. Meters that are not advanced meters are standard meters.



Metering is not a one-time event where equipment is purchased and installed; the application of meters to measure energy use will not result in any energy or utility cost savings. Instead, meters are a technology that enables improved energy management while metering is an on-going process. The strategic application and operation of meters and metering systems are critical elements of a metering program. To be successful a metering program must accomplish each of the steps listed below; all of the post-installation steps need to be completed on an on-going basis:

- Identify the objectives of the metering program prior to designing and purchasing metering equipment. What should be measured and why? What are the priorities? What is the budget?
- Design the metering systems to satisfy the identified program objectives.
- Purchase and install the metering systems as designed. This includes verification of system operation (commissioning).
- Operate the metering system to measure and record and store desired values.
- Compile and complete engineering analysis of data.
- Develop recommendations.
- Implement recommendations in a timely manner.
- Maintain the metering system.

The overall effectiveness of a metering program is the product, not the sum, of each of the steps listed above. If any of the steps are not successfully completed the benefits of the metering program will be minimized.

An effective metering program requires significant dedicated resources. However, the resulting benefits of energy and utility cost savings, along with improved equipment operation and reliability, make metering a great opportunity for federal agencies and facility managers.

Uses of Metered Data

There are many potential applications for metered data. Reasons to meter will vary by site, with some general examples listed below.

- Energy billing and procurement including measuring tenant energy use, verifying utility bills, identifying best utility rate tariffs, and participating in demand response programs.
- Measure, verify, and optimize performance including diagnosing equipment and systems operations; benchmarking utility use; identifying potential retrofit/replacement projects; and monitoring, diagnosing, and communicating power quality problems.
- Manage utility use including monitoring existing utility usage and utility budgeting support.
- Baseline development and measurement and verification (M&V) of savings in energy savings performance contracts (ESPC) and utility energy services contracts (UESC).
- Promote energy use awareness for building managers and occupants.

Many of these metering uses are further defined below.

Ultimately, numerous benefits from these metering uses will be realized:

- Reduced operating costs from reduced energy use and increased equipment life
- Optimized building and equipment performance—including improved systems reliability and increased occupant comfort.

Revenue Billing

Probably the most common use of metering is for billing purposes: utility companies install meters to charge customers for the amount of electricity they use. The data provided by a basic revenue meter is usually not very detailed, often consisting of nothing more than a monthly total of energy usage, and perhaps information on peak demand. More complicated rate structures can also require some time-of-use information, as described below. Nowadays, utilities are the only ones to collect and use this information, but the same metering system used by the utility could be used to provide customers with additional value by providing them with the energy-use information they need to plan their activities and manage costs.

Time-of-Use Metering

Many utilities and regulators are moving toward time-of-use rates, which charge more for the energy use contributing to the system peak demands, and also providing an incentive for utility customers to shift demand to off peak periods. Time-of-use rates require special meters to provide this information for billing purposes. EPAct Section 1252 addresses utility requirements for time-of-use metering (see text box below).

EPAct 2005, Section 1252 "Smart Metering"

EPAct 2005 requires that within 18 months of its enactment that states investigate and decide whether to mandate utilities to offer each customer a time-based rate schedule under which the rate charged by the electric utility varies during different time periods and reflects the variance, if any, in the utility's costs of generating and purchasing electricity at the wholesale level. The time-based rate schedule would enable the electric consumer to manage energy use and cost through advanced metering and communications technologies. If the states mandate time-based rate schedules, each electric utility would provide each customer requesting a time-based rate with a time-based meter capable of enabling the utility and customer to offer and receive such a rate, respectively.

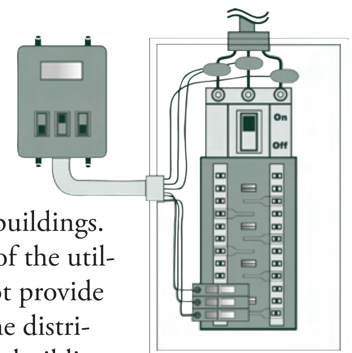
Real-Time Pricing

Somewhat similar to time-of-use metering in data requirements, a customer who receives power under a real-time pricing (RTP) contract has energy prices that change dramatically from season to season, and even hourly during periods of high system demand, such as during summer months. Being able to adjust purchased energy usage in response to these fluctuations in energy prices can save substantial amounts of money.

Load Aggregation

Agencies may want to combine facilities that are geographically separate from each other for purposes of acquiring and billing utility services. Such aggregation can result in lower utility rates than a separate utility account for each site. In some states with competitive commodity markets, it may be possible to aggregate loads, but there may be an increase in metering costs. In many cases, the loads may already be aggregated (such as at a military base), and the new meters will have the function of "disaggregating" the loads, but not the energy rate the facility receives. Agencies considering disaggregating loads are cautioned to include in their evaluation the potentially higher energy rates resulting from such an action.

Submetering



It is common for a single revenue meter to be installed by the utility for an entire campus of buildings. This serves the purposes of the utility company, but does not provide any information about the distribution of the load among buildings within the campus. Information about the loads at individual buildings can be used to equitably allocate energy costs.

Without building-level submetering, a utility bill is often allocated according to the square feet of building space that is occupied by tenant agencies or by some other technique that uncouples payments from the amount of energy used. For federal facilities, a fundamental principal should be that payments for utilities be based on measured usage, so there is an incentive for building occupants to conserve utility resources.

Energy Use Diagnostics

Understanding the way energy is used in a building can lead to changes in operation that reduce energy consumption. For example, if a large load exists at night when a building is unoccupied, there may be equipment running that should be shut off. Similarly, shifting equipment schedules can sometimes reduce demand charges from the utility companies by eliminating coincident and unnecessary equipment demands during peak periods. Other simple energy use diagnostics are related to comparison of energy use indices (EUI) such as the amount of kilowatt-hours used per square foot (kWh/SF). EUIs can be compared between similar buildings to determine if a building is using more energy than it should, or can be compared to historical data for the same building to determine if the building energy usage has increased. Observations in energy usage trends over time can indicate when equipment is in need of service.

Power Quality

Advanced meters can capture electrical anomalies such as transients, voltage disturbances, power factors, and harmonics in order to troubleshoot power quality problems. This can be especially useful when monitoring sensitive loads. Transients can cause premature failure of printed circuit boards in computers and other electronic equipment. Improper power factor can result in surcharges from utility companies. High harmonics can shorten the life of transformers. Using advanced meters will allow detection and documentation of power quality problems so solutions to those problems may be developed and implemented.

Measurement and Verification of ESPC Savings

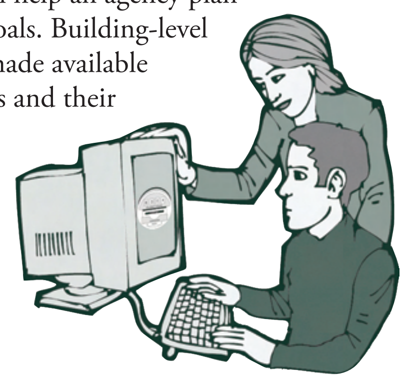
In the federal setting, energy savings performance contracts (ESPC) often involve the installation of conservation measures in a small number of buildings on a large campus-type facility that contains a single revenue meter. The savings generated by the ESPC are a small fraction of the facility's total energy use, and can be difficult to estimate project savings from analysis of monthly utility bills. For this reason, indirect methods such as modeling and engineering calculation are often used to estimate savings. If the buildings are individually metered, readings before and after the project can be used to establish both the energy use baseline and the energy savings to a much higher degree of confidence.

Emergency Response

During an electrical power emergency (such as experienced in California in 2000 and 2001), or during other utility shortages (such as the water drought in 2002), the manager of a federal facility may need real-time information in order to make decisions regarding physical plant closure or interruption of non-critical loads. A manager may want real-time feedback that his directions to staff to reduce power use are being followed and are achieving the required result.

Planning and Reporting

Managers of facilities that are distributed geographically may benefit from an advanced metering system that allows them to view and record energy use via the Internet. An advanced metering system can be designed to collect, reduce, and present information that would describe agency energy use and progress toward goals set by legislation and Executive Order, or other goals set by agencies. Carefully designed reports from advanced metering systems can help an agency plan how to meet these goals. Building-level reports can also be made available to building managers and their staffs, as well as tenants/occupants, as a way to increase their awareness and provide an opportunity to manage energy use proactively.



Metering Approaches and Technologies

Introduction

Metering provides the information that when analyzed allows the building operations staff to make informed decisions on how to best operate mechanical/electrical systems and equipment. These decisions will ultimately affect energy costs, equipment costs, and overall building performance. Metering can take place at a variety of points within an electrical or mechanical system and can encompass the collection of electricity, natural gas, water, steam, or other fluid data. The decision of where and what to meter is determined by your metering objectives and should be determined in your metering plan. While metering at the end-use or circuit level has application and will be described, our focus will center on higher-level, whole-building utility metering.

At the outset, it should be noted that metering in-and-of-itself saves no energy or dollars. In fact, it costs money to meter - the purchase and installation of the metering, the communications or meter-reading expense, and the time necessary to process and interpret data. A metering program can be a costly and time-consuming endeavor. The key to a successful metering program lies in the ability to make use of the output of a meter. Metered data needs to be converted to information from where actions and projects are developed and implemented.

Generic Approaches

The four predominant levels of resource metering (EPRI 1996) are:

- One-time/spot measurements (system/sub-system)
- Run-time measurements (system/sub-system)
- Short-term monitoring (system/sub-system/whole building)
- Long-term monitoring (system/whole building)

Each level has its own unique characteristics—no one monitoring approach is useful for all projects. A short description of each monitoring level is provided below.

One-Time/Spot Measurements

One-time/spot measurements are useful in many "baseline" activities to understand instantaneous energy use, equipment performance, or loading. These measurements become particularly useful in trending equipment performance over time. For example, a spot measurement of a boiler-stack exhaust temperature, trended over time, can be very diagnostic of boiler efficiency.

Related to energy performance, one-time/spot measurements are useful when an energy-efficiency project has resulted in a finite change in system performance. The amperage of an electric motor or lighting system taken before and after a retrofit can be useful to quantify system savings—assuming similar usage (hours of operation) before and after.

Equipment useful in making one-time/spot measurements includes clamp-on amp probes, contact and non-contact temperature devices, non-intrusive flow measurement devices, and a variety of combustion-efficiency devices. Most of these measurements are obtained and recorded in the field by the analyst.

One-Time/Spot Measurements Advantages

- Lowest cost
- Ease of use
- Non-intrusive
- Fast results

One-Time/Spot Measurements Disadvantages

- Low accuracy
- Limited application
- Measures single operating parameter
- Measurement at a single point in time

Note: *One-time spot measurements will not be sufficient to comply with the requirements of EPAct Section 103.*

Run-Time Measurements

Run-time measurements are made in situations where hours-of-operation are the critical variable. These measurements are prevalent where an energy efficiency project has impacted the use (i.e., hours of operation) of a device. Appropriate applications for run-time measurements include the run times of fans and pumps, or the operational characteristics of heating, cooling, or lighting systems.

Because run-time measurements do not capture the energy-use component of the system, these measurements are typically used in conjunction with one-time/spot measurements. Equipment useful in making run-time measurements includes a variety of stand-alone (battery-operated) data loggers providing a time-series record of run-time. Most of these devices are non-intrusive (i.e., the process or system is not impacted by their use or

Run-Time Measurements Advantages

- Low cost
- Relatively easy to use
- Non-intrusive
- Useful for constant-load devices

Run-Time Measurements Disadvantages

- Limited application
- Measures single operating parameter
- Requires additional calculations/assumptions
- Requires recover and/or manual data download

Note: *Depending on whether data is collected at least hourly, and automatically downloaded at least daily, run-time measurements may not meet the definition of advanced metering.*

set-up) and are either optically triggered or take advantage of the electromagnetic characteristics of electrical devices. Run-time measurements are usually obtained in the field by the device, recorded to memory, and then downloaded by the analyst at a later date.

Short-Term Measurements/Monitoring

Short-term monitoring combines both elements of the previous two levels into a time-series record of energy or resource use: magnitude and duration. Typically, short-term monitoring is used to verify performance, initiate trending, or validate energy efficiency improvement. In this level, the term of the monitoring is usually less than one year, and in most cases on the order of weeks to months. In the case of energy efficiency improvement validation, also known as measurement and verification, these measurements may be made for two-weeks prior and post installation of an efficiency improvement project. These data are then, using engineering and statistical methods, extrapolated over the year to report the annual impact.

Equipment useful in short-term monitoring includes a host of portable, stand-alone data loggers capable of multivariate time-series data collection and storage. Most of these data loggers accept a host of sensors including temperature, pressure, voltage, current flow, etc., and have standardized on input communications (e.g., pulses 4 to 20 milliamperes or 0 to 5 volts). These loggers are capable of recording at user-selected intervals from fractions of a second to hourly to daily recordings. These systems usually rely on in-field manual downloading or, if available, modem and/or network connections.

Short-Term Measurements/Monitoring Advantages

- Mid-level cost
- Can quantify magnitude and duration
- Relatively fast results
- Data can be recovered remotely over data lines

Short-Term Measurements/Monitoring Disadvantages

- Mid-level accuracy
- Limited application
- Seasonal or occupancy variance deficient
- More difficult to install/monitor

***Note**: Although short-term measurements have their advantages, EPAct Section 103 is directed at permanent, long-term metering installations.*

Long-Term Measurements/Monitoring

Long-term monitoring also makes use of time-series recording of energy or resource use, but over a longer duration, and is in line with the metering requirements of EPAct. Different from short-term use, this level focuses on measurements used in long-term trending or performance verification. The term is typically more than a year and quite often the installation is permanent. Metering at the whole-building level is typically a long-term, permanent installation.

Useful applications for this level of monitoring include situations where system use is influenced by variances in weather, occupant behavior, or other operating conditions. Other applications include reimbursable resource allocation, tenant billing activities, or in cases where the persistence of energy or resource savings over time is at issue.

Equipment useful in long-term monitoring includes a variety of data loggers, utility-grade meters, or fixed data acquisition systems. In most cases these systems communicate via a network connection or a phone modem to a host computer and/or over the Internet.

Long-Term Measurements/Monitoring Advantages

- Highest accuracy
- Can quantify magnitude and duration
- Captures most variance
- Data can be recovered remotely over data lines

Long-Term Measurements/Monitoring Disadvantages

- High cost
- Most difficult to install/monitor
- Time duration for result availability

***Note**: Long-term monitoring makes use of time-series recording of energy or resource use (but over a longer duration) and meets the requirements of EPAct.*

Metering System Components

With the focus of proposed legislation on whole-building metering, this section highlights the three necessary components to viable building-level metering systems: the meters, the data collection system, and the data storage/retrieval system (AEC 2003; EPRI 1996); the data analysis system/capability is discussed in the following section. Each component is described below.

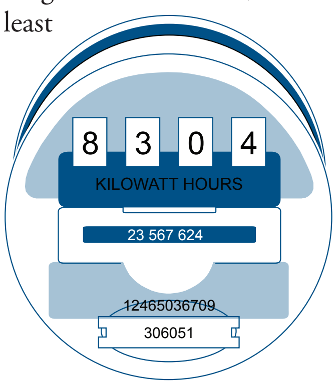
Meters

At the most basic level, all meters track and provide some output related to resource use - energy, water, natural gas, etc. Beyond this basic level, more sophisticated meters take advantage of additional capabilities including electrical demand tracking, power quality measurements, and multiple-meter communication.

For electrical systems, meters can be installed to track whole-building energy use (e.g., utility meters), sub-panel energy use (e.g., a lighting or process circuit), or a specific end use (e.g., a motor or a chiller). These meters usually involve current transformers (CTs), potential transformers (PTs) and some form of logic to calculate demand and power use. An increasingly useful electrical meter type is known generically as the *interval meter*. These meters measure electrical demand (kilowatts – kW) over a pre-determined interval—commonly every 15 minutes to match utility billing intervals. Other intervals (e.g., 1 minute, 5 minute, hourly) can be useful for examining equipment performance, trending, and start/stop characteristics. Electrical meters can be mechanical (i.e., electricity use is proportionate to movement of a mechanical dial), electro-mechanical (i.e., a mechanical meter with an electrical or pulse output), or solid-state/digital (i.e., no moving parts with output reported in a variety of digital formats).

New electrical metering should utilize digital metering technologies; retrofit applications should consider analog-to-digital conversion technologies. In either case, the technology should have at least hourly-interval-resolution capability.

A list of vendors of larger, dedicated, whole-building meters can be found in the report titled *Advanced Utility Metering* (AEC 2003).



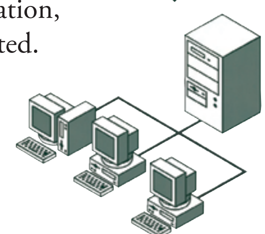
Data Collection

Modern metering data collection systems take advantage of recent developments in communications technologies. Over the past 15 years, Automated Meter Reading (AMR) systems have increased in sophistication and reliability, and now represent a very economic means of data collection. Available data collection technologies include the following:

- ***Manual read***: the outdated, yet still-practiced method of personal meter reading and key-in of values. This data collection practice is inefficient, inaccurate, and discouraged in most applications.

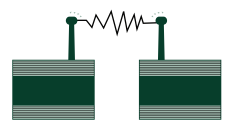
- ***Phone modem***: makes use of telephone modem technology both hardwired and cellular. While once considered to be state of the art, data communication via modem, compared with more advanced forms of communication, is now considered to be outdated.

- ***Local area network***: takes advantage of an existing building network communication system.



- ***Building automation system (BAS)***: using an existing BAS to move data from the meter to the point of analysis/storage can be a very economic method of data communication. Presence and capability of the BAS will determine the viability of this option.

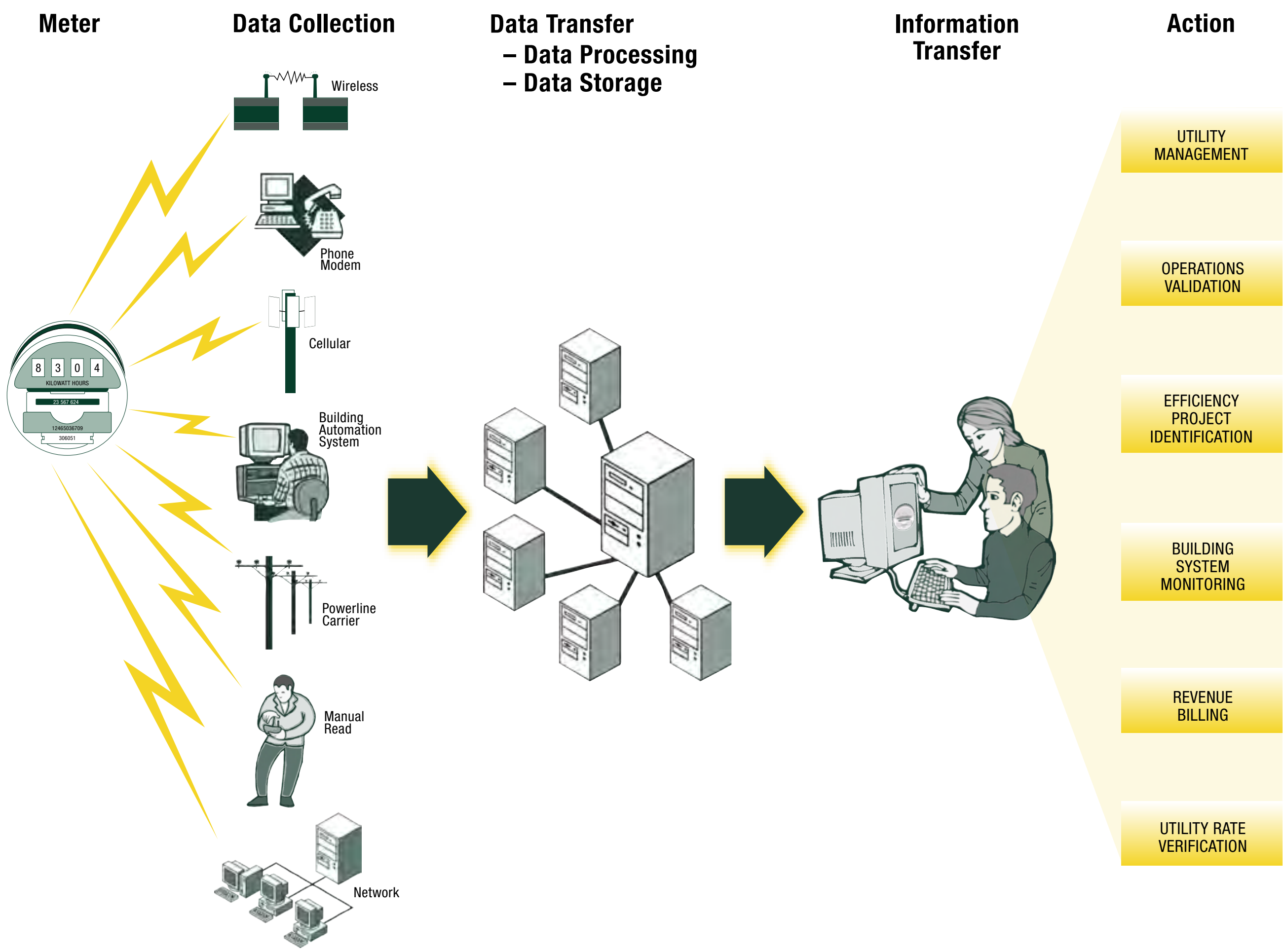
- ***Radio frequency (wireless)***: communications though radio frequency connections requiring little-to-no wiring. Caution needs be taken because of the potential for interference and communication through certain types of structural barriers.



- ***Power-line carrier***: using existing wiring either within or external to a building to communicate data.

Data Storage

The need for, and the duration of, data storage should be carefully considered in the design and implementation of a metering system. A clear understanding of data needs and applications will drive storage decisions. At the most basic level, metered data is easily stored in one of many available database systems. The duration of data storage is a function of data use; long-term end-use studies require longer duration storage, short-term daily comparisons require less. There are a variety of application service providers (ASPs) that can provide data collection, storage, and retrieval services on a fee-based structure.



Metering Cost-Effectiveness

Section 103 of EPAct 2005 requires that meters be installed at federal facilities "to the maximum extent practicable." For the purposes of this guidance, a practicable meter application is one that can be justified on the basis of its cost-effectiveness - a measure relating the estimated costs to the estimated savings, such as a simple payback period.

To determine cost-effectiveness we need to estimate

a) the cost to design, purchase, install, maintain, store data, and operate the meter/metering system, and analyze the data output, and

b) the resulting energy cost savings.

This section examines these components and demonstrates how an agency or site can evaluate the economic practicability of a metering application.

Developing a Metering Cost Estimate

Metering system costs vary widely for a number of reasons: equipment specifications and capabilities, existing infrastructure, site-specific design considerations, local cost factors, etc. For this reason, this guidance does not present cost estimates. Instead, we identify the main cost components that should be addressed when developing a metering cost estimate.

The metering cost estimate can be separated into three main categories: hardware, labor, and recurring costs. More detailed descriptions of these categories and the types of costs to be included are provided below.

Hardware: Hardware refers to the cost of the meters and all materials required to support their installation:

- Meter purchase cost. The purchase price depends on the features selected.
- Ancillary devices. Electric meters require current transformers (CTs) and safety switches. These devices may be built-in the meter but are usually purchased separately.
- Communications module. There are a number of types of communication modules that can be purchased for electric meters: Handheld reader communicator, telephone modem, radio transceiver, power line carrier modem, Ethernet modem, and SCADA interface RS232-RS485. Communications modules are usually ordered with the meter.
- Miscellaneous supplies. Small compared to other hardware line-item costs, miscellaneous supplies includes items such as the wire, conduit, and junction boxes necessary to complete the installation.

Labor: Labor covers the time charges for a crew (electric meters typically require a 2-person crew with an electrician and electrician's helper) and should account for planning and prep time, crew travel time, installation of all hardware required for a working installation, connection of communications module, operational testing, and inspection.

Recurring Costs: Recurring costs are planned regular costs that support the on-going operation of the meter/metering system.

- Monthly communications fees. These fees will vary based on communications method selected.
- Data collection and storage.
- Data analysis. Data need to be analyzed on a regular basis (daily and/or weekly) with findings and recommendations issued.
- Operation and maintenance. Meters require periodic calibration and testing.

Estimating Energy Cost Savings

The lack of federal metering experience makes it difficult to estimate the energy cost savings that can be expected from a site-wide metering program. Estimates of energy savings have ranged from 1 percent to 20 percent and more. Here are some results from non-federal sector submetering applications:

- New York State Energy Research and Development Authority Residential Electrical Submetering Manual (October 1997, revised October 2001) found that "the change from master-metering to submetering typically reduces the consumption of electricity in apartments by 10-26 percent."

- U.S. Environmental Protection Agency, in a 2002 paper "Submetering Energy Use in Colleges and Universities: Incentives and Challenges," provides case studies for submetering at two universities. In one case the university was able to reduce electric demand by 10 percent through demand aggregation. At the other university, a 10 percent reduction in electricity use was realized.

The following table presents metering-related savings ranges based on different uses for metered data.

Metering Savings Ranges

Action	Observed Savings
Installation of meters	0 to 2% (the "Hawthorne effect")[a]
Bill allocation only	2-1/2 to 5% (improved awareness)
Building tune-up	5 to 15% (improved awareness, and identification of simple O&M improvement)
Continuous Commissioning	15 to 45% (improved awareness, ID simple O&M improvements, project accomplishment, and continuing management attention)

For now, an estimated savings benefit of at least 2 percent seems reasonable and conservative, although agencies can consider using higher estimated savings per the cited examples. As more meters are installed in federal buildings, experience will provide agencies better examples of reasonable energy savings expectations.

Metering Justification Example

This section serves as an example to demonstrate a calculation procedure to estimate the minimum annual electric bill for a cost-effective meter installation. A metering system cost of $5,000 is used in the example for demonstration purposes only. Application-specific calculations should use an estimated metering system cost developed for the application being considered.

Assumptions:

1. Building-level electrical meter data analysis will save 2 percent of current annual electricity consumption.
2. Metering system installed costs is $5,000 per meter.
3. Desired simple payback: 10 years or less.
4. Monthly cost per meter of $25[3] including metering operations, maintenance, and data collection, storage, and analysis.

Formula and sample calculation:

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

= [($5,000) ÷ (10 years) + ($25per month) x (12 months per year) ÷ (0.02)] = $40,000

Results:

Given the above parameters, it is economic to meter any building that has an annual estimated bill over $40,000 to achieve a 10-year simple payback. The threshold for annual building electrical costs to justify cost-effective metering applications will vary by site based on metering costs and anticipated energy savings.

Factors Affecting Metering Costs

There are many factors affecting the cost for metering equipment. These factors include functionality, communications method, metering infrastructure, and site conditions. How a meter is purchased may also affect the price. For example, economies of scale may be realized if large purchases are made for a single site or if an agency or sites pool a purchase. Another example would be where meters are installed as a part of a larger project such as to provide measurement and verification as part of an energy savings performance contract.

[3] Monthly operations, maintenance, data collection, storage and analysis costs will vary by installation. For the purposes of this guidance, this monthly fee is estimated to most likely be in the range of $20 to $30 per month per meter.

Cost Justification Scenarios

Below are four scenarios with varied data inputs to give the reader a sense of the variety of metering costs, uses for data, and resulting savings where the minimum annual electric bill has been calculated using the formula and sample calculation on the previous page.

	Case 1	Case 2	Case 3	Case 4
Installed cost	$5,000	$3,000	$2,000	$2,000
Desired simple payback	10	10	10	10
Annual Costs for data collection & storage	$300	$300	$300	$600
% Annual Savings	2%	5%	10%	2%
Minimum Annual Electric Bill	$40,000	$12,000	$5,000	$40,000

In Case 1, we assume an installed cost of $5000 per meter, which will result in a 2 percent annual electricity savings per year over a ten year period. Annual costs for data collection, storage and maintenance amount to $300. Under this scenario, it would be practicable to install meters on any buildings or subsystems that use $40,000 or more in electricity per year.

In Case 2, the meters only cost $3,000 each, installed, and the agency plans a more active approach to using the data to obtain savings of 5 percent annually. In this case, it would make sense to install meters in buildings and/or subsystems that use at least $12,000 annually.

In Case 3, the agency plans to take advantage of a bulk purchase of thousands of meters that will results in an installed cost of only $2,000 per meter, and plans to implement a continuous approach to data analysis which leads to building tune-ups resulting in 10 percent annual improvements. In this case, the agency would install meters at all buildings or subsystems that use only $5,000 or more in electricity per year.

While standard meters might be cheaper to install on a first-cost basis, the data they provide, and the labor required to collect and analyze the data may mean that you won't be able to achieve the savings that an advanced metering system would enable. In Case 4, installing standard meters at $2,000 per meter nets a 2 percent annual savings, but these meters have higher annual operating costs, and therefore would not be practicable for buildings using less than $40,000 annually. In this case, it would be better to install higher cost advanced meters with lower annual operating costs and higher potential savings.

This is a greatly simplified comparison for illustration purposes. In reality, this analysis should consider the time value of money, and consider that savings from advanced metering systems might be greater in the earlier years than at year 10. A rigorous program of retro-commissioning based on advanced metering data might lead to early savings of 30-40 percent, but would not be sustainable at that level for the entire ten-year period of analysis.

DOE recommends a life-cycle cost comparison of various metering options for the best possible decision.

In order to estimate potential energy cost savings, we also need to have an idea of how much energy a building or mechanical/electrical equipment uses. Since the buildings are not already metered (as a metering justification would no longer be needed), we need to look at some other possible methods to estimate building energy use.

One method is to apply some of the general approaches outlined in the Metering Approaches and Techniques section: one-time/spot measurements and/or run-time measurements for system and subsystem metering, and short-term measurements for whole building monitoring. In cases where buildings are not metered, electric energy use can be estimated using energy-use intensity (EUI) data appropriate for the building type, DOE's Facility Energy Decision System (FEDS) software, or other private-sector computer models.

Data Source for Building EUIs

A building's energy use is sometimes characterized as the energy usage intensity, or EUI (typically given in units of energy use/ft^2/year). One source of commercial building EUI data is DOE's Buildings Energy Databook available online at http://buildingsdatabook.eren.doe.gov/. This approach does have its limitations as a building's energy use is driven by many site-specific variables and characteristics that may approach, but not exactly match, generalized EUI estimates.

Methods for Prioritizing Buildings for Metering Applications

Section 103 of EPAct 2005 states that "all Federal buildings shall...be metered. Each agency shall use, to the maximum extent practicable, advanced meters or advanced metering devices ..."[5] Clearly, it is not practicable to meter all of the estimated 500,000 buildings[6] in the federal building inventory. Instead, agencies should prioritize buildings (and equipment) for metering/submetering applications based on the potential to benefit from the metered data. Metering benefits can be estimated in a number of ways.

Cost-effectiveness is usually the driver for determining the applicability and priority of energy efficiency projects. In the case of meters, the cost-effectiveness is based primarily on the cost of the equipment and its support (on-going operations, maintenance, and data analysis), and the resulting energy and other cost savings realized from the application of the meter—again, the same as for an energy efficiency project.

Each agency will need to develop its own method(s) of estimating the applicability of meters to buildings and energy intensive equipment, and prioritizing applications across its building inventory. Since the applicability of meters will often be addressed at the site level, here are the primary factors that must be addressed:

- The amount of electricity (energy) used in a building is based on a number of factors including, but not limited to, the building size, type of use (e.g., office, healthcare, food service, storage), age, climate zone, orientation, operating hours, and occupancy.
- The cost of electricity (energy and demand) will also impact the cost-effectiveness of the metering application—higher energy rates will result in more cost-effective applications.
- The expected/estimated benefits from the metering program will vary by objective—cost allocation/tenant billing, participation in utility-offered demand response programs, on-going commissioning, etc., may each offer a different estimated benefit (savings).

Assessment and Prioritization Approaches

There is a lot of flexibility in how sites can go about determining the cost-effectiveness and subsequent priority of building meter applications. An example of determining the potential cost-effectiveness of metering appears in the Metering Cost-Effectiveness section. It is highly recommended that a detailed approach be spelled out in the agency or site metering plan. Below are two possible approaches that agencies and sites may consider using or adapting when developing their metering plans.

Approach 1: Contracted Metering Plan Approach. Contract the development of a site-wide metering plan to a qualified energy management consulting firm. The contract scope should include a review of all buildings on a site building inventory list with suggestions for metering approaches and prioritization of meter installations based on estimated benefits. Prior to issuing the contract, the site will need to determine the objectives of its metering program so that the objectives can then be incorporated into the statement of work.

Advantages:

- Many engineering firms having existing capability with established expertise in building and equipment energy metering. However, sites must verify capabilities prior to issuing a contract.
- Engineering firms (should) have equipment to perform spot measurements and short-term monitoring. These types of measurements allow for more detailed estimates of building and equipment energy use.

Disadvantages:

- Requires up-front funding
- A contract development and management effort is also required. A successful contract requires a well-written statement of work, effective contract management and administration, and a good working relationship between the site and the contractor.

Approach 2: In-house Metering Plan Approach. Complete site-wide metering plan development using in-house staff. This approach is, in effect, the same approach as

[5] See Appendix B, Energy Policy Act of 2005 Federal Metering Requirements, for complete text.

[6] Annual Report to Congress on Federal Government Energy management and Conservation Programs Fiscal Year 2002, September 29, 2004.

Approach 1, except the site staff are used instead of contracted staff. A related approach would be to contact and work with the local utility to develop the metering plan.

Advantages:

- In-house staff typically cost less than consulting firms and many times have a better handle on building energy use.
- Does not require contract development, award, and administration.

Disadvantages:

- In-house staff may lack expertise in building (and equipment) energy metering.
- In-house staff may lack spot measurement and short-term monitoring capabilities.
- In-house staff may have competing project priorities.

Considerations to Simplify Building Prioritization

As previously mentioned, there are many factors that will impact the overall building energy use. Here are some building attributes that will typically result in non-cost-effective metering applications

- Low energy intensity buildings - such as unconditioned warehouses and low occupancy/seasonably occupied buildings. Care should be taken to verify that these typically low intensity buildings are in fact low energy using—that is, they do not house energy intensive equipment/systems and are not of sufficient size that application of meters becomes cost effective.
- Small buildings. Agencies should review their building inventory and develop a guideline that defines a "small" building. However, a small building can be energy intensive based on its use: laboratories, food service, and health care facilities are examples of small buildings that may use a lot of electricity and should be considered for potential metering application.
- Leased buildings where reduction in energy use will not benefit the federal government (i.e., full-service leases).
- Leased buildings with contract terms shorter than the estimated simple payback period for a meter application. (Agencies should provide guidance on determining the remaining lease term and possible renewal options.)

Periodically Revisit Your Building Priority Lists

Finally, the priority listing of buildings should be revisited and re-ordered as necessary to accommodate changing economics brought on by changes in utility rates and/or rate structures, changing costs in metering equipment and their operation and maintenance, or lessons learned regarding the resulting benefits of previous metering applications. Also keep in mind that the building priority lists need to be revised to reflect the installation of meters at the site.

Methods of Financing

Metering existing facilities to comply with recommendations will be costly in terms of initial investment. Agencies and sites will have to identify funding mechanisms that best suit their needs.

The following table offers a brief listing and summary of potential funding mechanisms available to federal sites looking to purchase and install metering equipment and systems. Experience with these funding mechanisms varies from little to well-understood, and success will vary by site and agency. Some of these mechanisms have not yet been attempted and are listed not only because they may have potential, but also because of the reality that competition for facility funds is very intense and new initiatives may require creative financing approaches. Readers are encouraged to think beyond this list and develop approaches that best suit their agency and needs.

Beyond the initial investment, funding to cover the on-going operations, maintenance, data analysis, and implementation of recommendations is not addressed in this section. These activities are largely human resource intensive and require an upfront commitment prior to the system design and installation.

Summary of Potential Metering/Submetering Funding Mechanisms Available to Federal Sites and Agencies

Funding Mechanism	Description	Advantages	Disadvantages
Agency appropriations	Fund using agency appropriations. Most likely local funding but funding can be designated as dedicated at headquarters level. Metering must compete against other initiatives for funding.	Traditional funding approach – no surprises. Potential use of utility funds may provide some local flexibility.	Funds tend to be very limited.
Retained energy savings	Agencies with statutory authority are permitted to retain and reinvest a portion of the savings in additional efficiency initiatives. (Section 102 EPAct 2005)	Competition limited to other efficiency measures.	Retained energy savings are not widely applied. Check with your agency on its policy.
Energy Savings Performance Contracts (ESPCs)	ESPCs may offer several approaches that support or promote the installation of advanced metering systems: – Install as part of measurement and verification effort – Install meters as an energy conservation measure (e.g., peak load management) – Purchase meters using a portion of the realized project savings – Install as an energy conservation measure with resulting savings realized stipulated	In cases where ESPCs are in place, new delivery orders can be placed and/or savings streams tapped. Advanced metering systems make possible several new energy conservation measures such as real time purchasing, peak load management, and on-going retro commissioning. Measurement and verification will be much more rigorous and reliable than other M&V methods.	Meters for M&V may affect cost-effectiveness of measures. Likely reluctance to allow for stipulated savings resulting from installation of meters. More data (case studies) needed. True cost of meters now includes interest payments over the life of the contract.
Utility Energy Services Contracts (UESCs)	UESCs have been widely used to install/update new facility mechanical/electrical systems.	UESC approach used widely across the federal sector. Investment paid back through utility bills.	Subject to availability on individual utility basis. Site should work to ensure that savings will result so that utility bill does not increase over budgeted amount. True cost of meters now includes interest payments over the life of the contract.
Utility company financing	Under utility areawide contracts, utilities can offer federal sites a range of services offered to other customers. While service offerings will vary by utility, examples of potential services include – Assistance in designing a metering plan – Utility covers up-front cost to purchase and install with repayment included as a fixed facility charge on bill for a set number of years – Subscription services where customer pays a fee for information but does not own, operate, or maintain metering equipment.	Utility services are frequently offered by utilities to all customers in their service territory. Federal sites should tap into this pool of services when advantageous.	Services may not be offered by local utility.
Bonneville Power Administration (BPA)	For several years BPA has been working with federal sites to provide low-interest financing in support of energy efficiency measures. Requests for funding are bundled together allowing BPA to shop for the best available interest rates.	Performance guarantees not required in this approach.	Non-traditional funding approach. True cost of meters now includes interest payments over the life of the contract agreement.

Summary of Potential Metering/Submetering Funding Mechanisms Available to Federal Sites and Agencies (contd)

Funding Mechanism	Description	Advantages	Disadvantages
Public benefits programs and utility demand response programs	States and/or utility service areas with potential electrical capacity problems may make funding available that allows customers to participate in programs where they can better manage loads.	Funds are "free" when qualifications are satisfied.	Only a limited number of states and utilities currently offer financial incentives to install advanced metering systems.[a] Funding will likely cover only a portion of the purchase cost of the meters—additional funding will still be required.
Require as part of new building and major renovations projects	This approach relies on establishing policy that requires installation of meters/sub-meters as part of major capital projects.	Cost to purchase and install is absorbed as part of the overall construction cost.	Ensuring requirement is not "value engineered out."
Mandatory tenant submetering fees	Initiate a policy where tenants are billed the costs to purchase, install, and operate a metering/submetering system for their assigned facilities.	The approach assigns the cost to the party that can most benefit in terms of accurate billing and more efficient systems operations.	Tenants will protest additional cost, especially if they don't see benefit.
O&M performance incentives	Federal Acquisition Regulations (FAR), Subpart 16-404 Fixed Price with Award Fees, allows for contractors to receive a portion of savings realized from actions initiated on their part that are seen as additional to original contract. O&M performance incentives attempt to capitalize on this provision by awarding fees for contractors completing low-cost and no-cost measures not specifically called out in the contract. Contractor fee would be a part of the energy savings realized. Contractor can install advanced meters and use data to optimize buildings to achieve award eligible savings.[b]	Can be a no-cost approach to install meters as contractor may agree to pick-up purchase, installation, and operations costs.	There are no known examples of O&M performance incentives in federal buildings. Agreeing to terms with the O&M contractor may require significant negotiation. Performance incentives awards requires on-going oversight.
Lease metering equipment	Lease advanced meters from GSA Federal Supply Service similar to leasing of other equipment.	Can pay out of utility account so savings can cover lease payments. Less up-front funding needed.	Periodic leasing fees vs. one-time expense when purchasing.

a Information on state energy efficiency funds and demand response programs is available on the FEMP utility Web site: http://www.eere.energy.gov/femp/program/utility/utilityman_energymanage.cfm. Check with your state energy office and servicing utilities to verify and/or obtain information on current program offerings.

b See Section 3.8.1, Contract Language, of the FEMP O&M Best Practices Guide for more information on O&M performance incentives.

Template for an Agency Metering Plan

EPAct 2005 requires each federal agency to develop a plan and submit it to DOE/FEMP no later than August 3, 2006. The agency plans will address implementation of the metering requirements by the end of FY 2012.

Know Your Local Utility

Agencies are encouraged to consult with their local utility during the development of their metering plans. This will ensure that the metering equipment purchased is compatible with the existing utility billing meter and/or any upgrades the utility is planning for its system. Consulting with the local utility will also help to avoid the possibility of the site installing a site-owned advanced meter directly behind a utility-owned meter that is scheduled to be replaced by the utility with advanced metering equipment, resulting in the site paying for two advanced meters. The local utility will also be able to help the site determine what if any impact the installation of advanced meters or sub-meters technology may have on utility rates, coincident peak billing determinants, or a site's ability to participate in demand response programs. Many utilities offer advanced metering services under PUC-approved tariffs. Federal sites are able to procure these utility services on a sole source basis through the use of the GSA Areawide Contract, a basic ordering agreements, or a site-specific contract. The option greatly simplifies the acquisition process for agencies.

This section provides a template for agency metering plans, recognizing, of course, that one size does not fit all, and that each agency will likely have a slightly different approach. However, the following sections apply to all federal agencies:

Goals

- Formalize the agency's metering program goals. An example of an overall goal for an agency might be: to fully implement advanced electric metering at all facilities wherever practicable, by 2012.
- Identify and confirm the objectives and target dates of the users/stakeholders. Objectives should relate to the various uses of metered data, such as bill allocation, demand management, continuous commissioning, etc., with the ultimate goal being to reduce electricity usage and costs. An example of one possible objective might be to fully enable energy bill allocation at all agency branch levels.
- Prioritize objectives as near-term, mid-term, and long-term.
- Formalize to outcomes of each objective. For example, if an objective is to enable full bill allocation, an outcome of this might be a reduction in overall electric costs of 10 percent.

Metering program structure

- Data needs – Once clear goals and objectives have been identified and agreed upon by all users/stakeholders, how exactly will the agency go about implementing its plan? The starting point would be to identify data needs that will support the goals and objectives. For example, if an objective is to fully enable bill allocation at all agency branch levels, then a minimum data requirement would be to collect kWh and kW data at those buildings or portions of buildings inhabited by the various branches, and to have the ability to identify and notify each organizational unit of its electric consumption and demand on a periodic basis.
- Analysis methodologies – Data, by itself, isn't of much use without some analysis to determine what it means. ***This is a central and critical point in developing any successful metering program***. There are many tried and true methods of trend analysis, for example, and many commercially available software tools and service providers that can help make sense out of the enormous amounts of data.
- Equipment needs – based on the data requirements and analysis methodologies identified in the previous steps, what types of metering/monitoring equipment and hardware/software tools would be most appropriate to provide that data?
- Existing infrastructure – do a cross-walk of equipment and analysis needs with the existing agency infrastructure to identify where existing meters and metering systems can be put to better use, and to identify where the gaps are. Tie into existing EMCS

wherever practicable.

- Staffing requirements – make sure the lines of responsibility and commensurate authority are clearly in place for successful implementation of the plan.

Criteria for evaluation of metering costs, benefits, and impacts to existing systems, infrastructure and staff

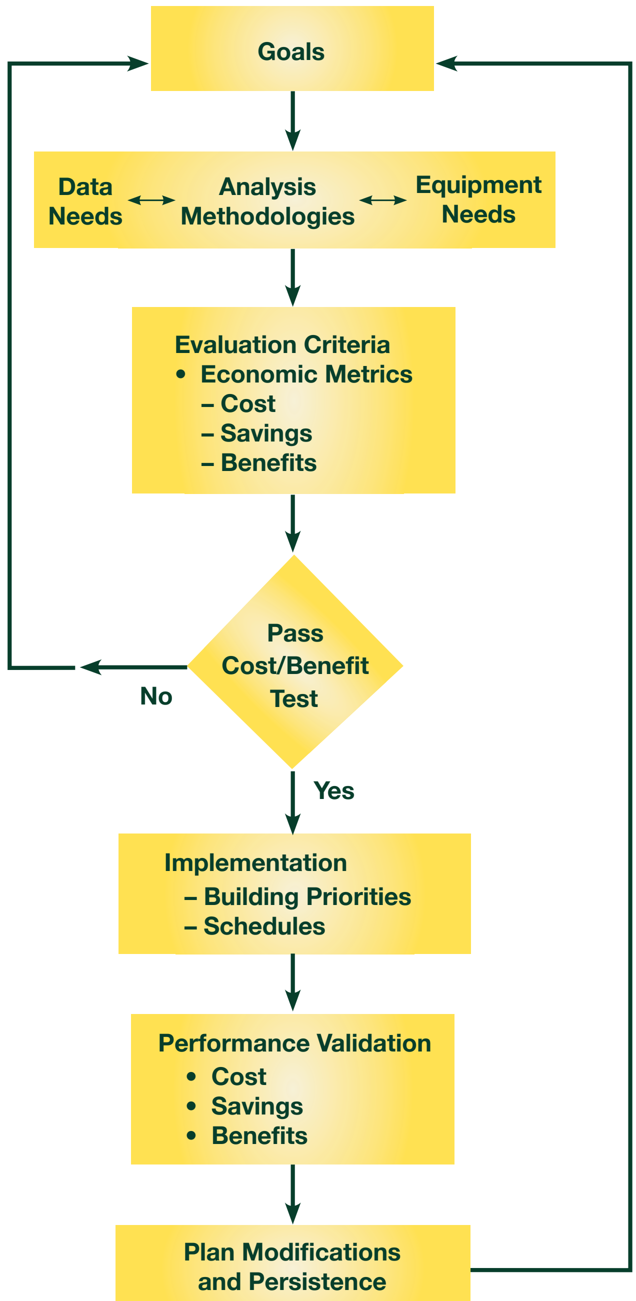
- Determine the relative economics of metering and advanced metering systems.
- Justify with cost/benefit, life-cycle cost, ROI or payback metrics. For example, basic use of metered data might provide a 2-5 percent savings on the cost of electricity, while comprehensive continuous programs might result in 30-40 percent savings.

Prioritized implementation plan

- Screen opportunities based on success potential. Generally speaking, the largest energy users will most likely net the best results in terms of the cost of meter installation. The 80-20 rule might well apply to your agency. In other words, eighty percent of the opportunity might lie in 20 percent of the buildings. Develop a prioritized list of your buildings/facilities that reflects the cost of metering, the potential benefits based on your objectives, and the best available data on building/facility energy use. At some point in prioritizing your building inventory, you will most likely find a cut-off line where advanced metering no longer makes sense economically.
- Develop a timeline for full implementation of advanced metering installation at all buildings and subsystems wherever found to be practicable.
- Provide for periodic updates of economic criteria/evaluation so that your plan is up to date with current technology and energy costs.

Performance measures

- Provide performance measures to track your progress towards full implementation of Section 103 of EPAct. Performance measures can take a number of forms, but should relate to the overall goal of installing meters and advanced meters wherever found to be practicable and cost effective. At a basic level, your measures should be expressed in terms of number of buildings metered and the corresponding electrical energy usage represented by those buildings. See the following section for further discussion.



Metering Plan Development Process

Performance Measures

To ensure that the federal government is on track for compliance with EPAct Section 103 by the end of FY 2012, it will be necessary for DOE to report on the progress that agencies have made each year. For the FY 2006 reporting period, DOE will request that you submit your metering implementation plan. In subsequent years (FY 2007 through FY 2012), DOE will ask that you report agency-wide progress on an annual basis, in conjunction with existing agency reporting requirements.

As shown in the following table, DOE will require agencies to report both the number of buildings metered and the percentage of agency electricity consumption represented by those buildings, and to distinguish between standard meters and advanced meters for each year, except for FY 2007. The FY 2007 report should include the total number of buildings already being metered. Reporting on advanced meters will not take place until FY 2008. All reporting should be on a cumulative basis.

Reporting Progress in Federal Buildings

	Standard Meters		Advanced Meters	
FY	Cumulative # of Buildings Metered	Cumulative % of Electric Metered	Cumulative # of Buildings Metered	Cumulative % of Electric Metered
2007				
2008				
2009				
2010				
2011				

Special Considerations

In developing a metering program, agencies must consider a variety of site-specific factors that may affect their program design. Listed below are a number of factors to consider.

- Leased versus owned or delegated – Many, if not all, agencies occupy buildings that are owned by others, or delegated, with varying levels of responsibility for payment of energy bills. The decision on whether to install metering in leased buildings must be based on several factors:
  - – Is the agency responsible for payment of electric bills?
  - – Is the term of the lease sufficient to justify the cost of advanced metering installations?
  - – Who has control over the operation of the facility?
  - – Is the landlord amenable to installing meters?
  - – Can the lease be modified to clarify metering responsibilities?
- O&M Contracts – Many federal facilities are operated by contractors, and the trend is moving further in that direction. These contracts should be examined to determine how they can be modified to require contractors to incorporate metering technology into the building operating systems, and to hold them accountable for building energy performance as well.
- New versus existing construction – Many agencies already require meters to be installed in all new construction and major renovations, and this practice should be replicated across the federal government. Many existing buildings are already metered, but should be examined along with the entire building stock to determine whether it would be cost-effective to upgrade to advanced metering systems wherever practicable.
- Metering of other utilities – While EPAct specifically refers to advanced metering for the purpose of reducing electricity usage and cost in federal facilities, DOE strongly encourages the use of advanced metering technologies for other purchased utilities as well, since they make up a substantial portion of energy consumption.
- Building level versus system level – advanced metering should be considered not only at the whole-building level, but as far down into the subsystem level as practicable.

- Hourly data versus more detailed – Although EPAct 2005 specifically calls for installation of advanced electric meters that are capable of at least hourly readings and at least daily data retrieval, advanced metering systems provide much higher capability than that, and the benefits of more granular data collection and analysis are considerable.
- When to retrofit existing meters? – You should analyze existing metering configurations to determine where replacement with newer, advanced metering systems would be cost-effective in the same way that you analyze non-metered buildings and subsystems.
- What about excess facilities or Base Realignment and Closure Commission (BRAC) buildings? – If you plan to excess or BRAC a building in the near future, it may not make sense to invest in metering at those locations. However, if the investment in metering would pay for itself prior to the closure/transfer, you should consider it as a viable option. If the closure won't take place for 7 years and meters show a 3-year payback, for example, then you should proceed with the metering installation.
- Should we meter overseas facilities? – All agency buildings and industrial and process facilities are subject to the requirements of EPAct, no matter where they are located.

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Periodically visit the FEMP O&M Web site for additional information on building energy metering: www.eere.energy.gov/femp/operations_maintenance/

Appendix A

Advanced Metering Terms and Definitions

Advanced Meters – Advanced meters are those that have the capability to measure and record interval data (at least hourly for electricity), and communicate the data to a remote location in a format that can be easily integrated into an advanced metering system. EPAct Section 103 requires at least daily data collection capability.

Advanced Metering Device – A separate electronic device coupled to a standard meter that enables it to function as and meet the definition of an advanced meter.

Advanced Metering Infrastructure – The communications hardware and software and associated system and data management software that creates a network between advanced meters and utility business systems which allows collection and distribution of information to users.

Advanced Metering Systems – A system that collects time-differentiated energy usage data from advanced meters via a network system on either an on-request or defined schedule basis. The system is capable of providing usage information on at least a daily basis and can support desired features and functionality related to energy use management, procurement, and operations.

Automatic Meter Reading (AMR) – A system where aggregated kWh usage, and in some cases demand, is retrieved via automated means such as a drive-by vehicle, or walk-by hand-held system.

Critical Peak Pricing – A type of dynamic pricing whereby the majority of kWh usage is priced on a time-of-use (TOU) basis, but where certain hours on certain days where the system is experiencing high peak demand are subject to higher hourly energy prices that reflect market conditions for peak generation and delivery during peak demand periods. These critical period prices may be known to electricity customers under conditions such as "day-ahead" or "hour ahead" and are typically employed a limited number of times per year.

Demand Response – Demand response refers to the reduction of customer energy usage at times of peak usage in order to help address system reliability, reflect market conditions and pricing, and support infrastructure optimization or deferral. Demand response programs may include dynamic pricing/tariffs, price-responsive demand bidding, contractually obligated and voluntary curtailment, and direct load control/cycling.

Direct Load Control – A system or program that allows utilities, other load serving entities, or demand response service providers to control user load via 1) directly cycling discretionary load of certain end uses, 2) directly turning off such loads or 3) implementing custom load control strategies that reduce peak usage.

Dynamic Pricing – Retail prices for energy consumed that offer different prices during different time periods and reflect the fact that power generation costs and wholesale power purchase costs vary during different time periods. Types include Time-of-Use Pricing, Critical Peak Pricing and Real-Time Pricing.

Economic Demand Response Programs – Programs which encourage demand reductions via price signals to energy users that reflect the higher costs of electricity production and delivery at times of system peak.

Emergency Demand Response Programs – Programs which are dispatched by system operators when system operating reserves drop to levels such that load reductions are needed to maintain short-term system reliability.

Interval Meter – A meter that measures and records kWh usage on either predetermined or remotely configurable time intervals, where the intervals are in increments such as minutes or hours.

Load Management – A term used to refer to interruptible rates, curtailment programs and direct load control programs.

Real-Time Pricing – Energy prices that are set for a specific time period on an advance or forward basis and that may change according to price changes in the generation spot market. Prices paid for energy consumed during these periods are typically established and known to consumers a day ahead ("day-ahead pricing") or an hour ahead ("hour-ahead pricing") in advance of such consumption, allowing them to vary their demand and usage in response to such prices and manage their energy costs by shifting usage to a lower cost period, or reducing consumption overall.

Retrofitted Meter – A standard meter that has had an advanced metering device added to it.

Smart Meter – A different term used to refer to an advanced meter.

Standard meters – Electromechanical or solid state meters that cumulatively measure, record and store aggregated kWh data that is periodically retrieved for use in customer billing or energy management. Meters that are not advanced meters are standard meters.

Time-of-Use Pricing – Energy prices that are set for a specific time period on an advance or forward basis, typically not changing more often than twice a year (summer and winter season). Prices paid for energy consumed during these periods are pre-established and known to consumers in advance of such consumption, allowing them to vary their demand and usage in response to such prices and manage their energy costs by shifting usage to a lower cost period, or reducing consumption overall. The time periods are pre-established, typically include from two to no more than four periods per day, and do not vary in start or stop times.

Appendix B

Energy Policy Act of 2005 Federal Metering Requirements

SEC. 103. ENERGY USE MEASUREMENT AND ACCOUNTABILITY.

Section 543 of the National Energy Conservation Policy Act (42 U.S.C. 8253) is further amended by adding at the end of the following.

"(e) METERING OF ENERGY USE.—

"(1) DEADLINE.—By October 1, 2012, in accordance with guidelines established by the Secretary under paragraph (2), all Federal buildings shall, for the purposes of efficient use of energy and reduction in the cost of electricity used in such buildings, be metered. Each agency shall use, to the maximum extent practicable, advanced meters or advanced metering devices that provide data at least daily and that measure at least hourly consumption of electricity in the Federal buildings of the agency. Such data shall be incorporated into existing Federal energy tracking systems and made available to Federal facility managers.

"(2) GUIDELINES.—

"(A) IN GENERAL.—Not later than 180 days after the date of enactment of this subsection, the Secretary, in consultation with the Department of Defense, the General Services Administration, representatives from the metering industry, utility industry, energy services industry, energy efficiency industry, energy efficiency advocacy organizations, national laboratories, universities, and Federal facility managers, shall establish guidelines for agencies to carry out paragraph (1).

"(B) REQUIREMEMENTS FOR GUIDELINES.—The guidelines shall—

"(i) take into consideration—

"(I) the cost of metering and the reduced cost of operation and maintenance expected to result from metering;

"(II) the extent to which metering is expected to result in increased potential for energy management, increased potential for energy savings and energy efficiency improvement, and cost and energy savings due to utility contract aggregation; and

"(III) the measurement and verification protocols of the Department of Energy;

"(ii) include recommendations concerning the amount of funds and the number of trained personnel necessary to gather and use the metering information to track and reduce energy use;

"(iii) establish priorities for types and locations of buildings to be metered based on cost-effectiveness and a schedule of one or more dates, not later than 1 year after the date of issuance of the guidelines, on which the requirements specified in paragraph (1) shall take effect; and

"(iv) establish exclusions from the requirements specified in paragraph (1) based on the de minimis quantity of energy use of a Federal building, industrial process, or structure.

"(3) PLAN.—Not later than 6 months after the date guidelines are established under paragraph (2), in a report submitted by the agency under section 548(a), each agency shall submit to the Secretary a plan describing how the agency will implement the requirements of paragraph (1), including (A) how the agency will designate personnel primarily responsible for achieving the requirements and (B) demonstration by the agency, complete with documentation, of any finding that advanced meters or advanced metering devices, as defined in paragraph (1), are not practicable.

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