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Evaluation of Advanced Power Meters for Forest Service Facilities

Evaluation of Advanced Power Meters for Forest Service Facilities

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Introduction

The more Forest Service, U.S. Department of Agriculture, facility managers know about energy use trends in their facilities, the better equipped they will be to manage their facilities for energy efficiency. Advanced metering technology can monitor the amount of energy used at a facility and how the usage changes over time. Metering information can be collected for entire facilities or for specific areas, such as a shop. Managers can use the data acquired from these metering systems (figure 1) to identify ways to save energy and to document the cost savings afterward.

The Energy Policy Act of 2005 (Public Law 109-58) requires that all Federal buildings be metered to monitor the amount and efficiency of electricity usage by 2012. Individual agencies are required to develop policies that comply with the act (*http://www1.eere.energy.gov/femp/regulations/epact2005.html*).

The Forest Service will require that advanced meters and advanced metering systems be installed in buildings larger than 10,000 gross square feet (see sidebar for definitions of advanced meters and metering systems). The Forest Service intends to collect data from the metering systems periodically so the data can be used to analyze energy conservation strategies.

Figure 1—A typical high-end meter suitable for monitoring the electrical feed from an electric utility to a Forest Service facility.

Some Federal buildings do not have individual meters. Monitoring energy usage at these facilities is difficult without advanced metering systems.

Advanced Meters

Advanced Meters—Meters that can measure and record data at specified intervals (the Forest Service's specifications require a 15-minute interval) and communicate the data to a remote location in a format that can be easily integrated into an advanced metering system. The meters must collect data daily or more frequently.

Advanced Metering System—A system that collects time-differentiated energy use data from advanced meters over a network as scheduled or as requested. The system can provide daily energy use data and can support features related to energy use management, procurement, and operations.

Highlights...

- The Forest Service will require advanced power meters and advanced metering systems for buildings larger than 10,000 gross square feet.
- Facility managers can use data collected by the meters to identify opportunities for energy savings.
- The Missoula Technology and Development Center installed and evaluated four advanced power meters produced by two manufacturers.
- The PowerLogic ION Enterprise software, which allows persons to view metering data using a Web browser, was recommended for Forest Service use.

Project Objectives

The Missoula Technology and Development Center (MTDC) was asked to identify requirements and specifications for installing advanced meters and metering systems in Forest Service facilities. The systems need to provide information that can be used by the Forest Service nationally, but still be useful to individual facility managers.

This report is the project record of the center's evaluation of advanced meters and metering systems. It provides recommendations and considerations for installing and commissioning meters as well as for the software and communication networks needed to transmit data.

Understanding Advanced Meters and Metering Systems

It is important to understand why advanced metering systems are being used, the components of metering systems, the uses for data collected by the metering systems, and the benefits of long-term monitoring.

Reasons To Monitor Energy Usage

Advanced metering systems can provide data to help facility managers improve energy management.

Steps to developing a successful metering program include:

- Identify the objectives of the metering program before designing and purchasing meters.
  - ◊ What should be measured and why?
  - ◊ What are the priorities?
  - ◊ What is the budget?
- Design the metering systems to satisfy the program's objectives.
- Purchase and install the metering systems.
- Commission the metering systems to verify that they are operating correctly.
- Operate the metering systems to measure, record, and store desired values.
- Complete engineering analysis of the data collected by the metering systems.
- Develop recommendations that will help conserve energy.
- Implement recommendations in a timely manner.
- Maintain the metering systems.

The benefits of a metering program will depend on how successfully these steps have been implemented and whether they continue to be implemented after the metering systems have been installed.

Metering System Components

Metering systems include three components: the meters, the data collection system, and the data storage and retrieval system. Together, these components provide information that can be analyzed to help conserve energy (figure 2).

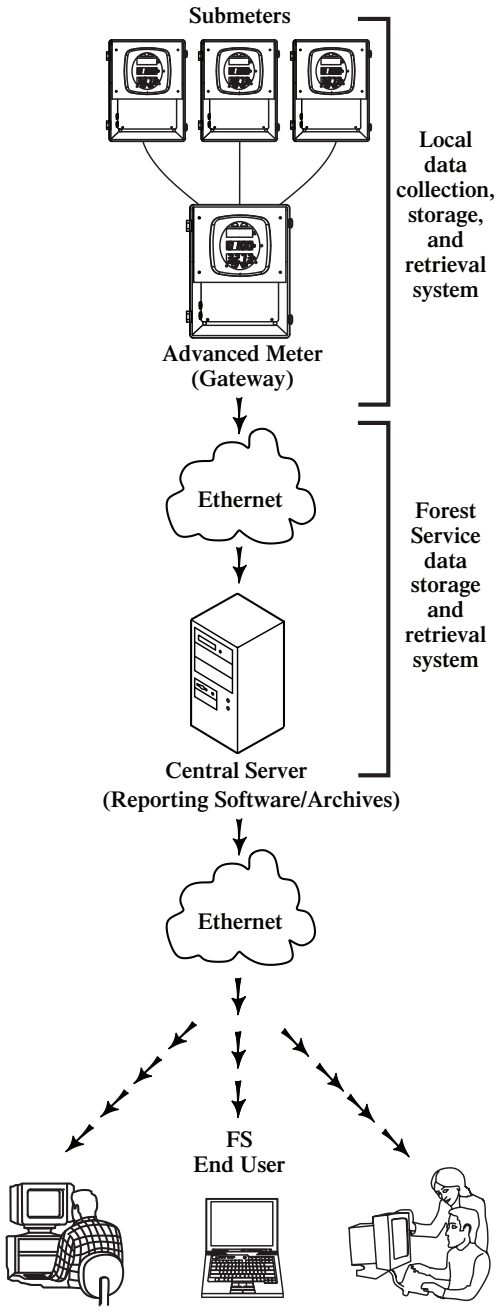

Figure 2—A diagram of the data flow from the meters to the end users.

Power Meters

Basic residential electric, water, and natural gas meters are read manually. More sophisticated power meters used in advanced metering systems are automated, allowing them to track electrical power demand and power quality while they communicate with other meters that provide specific types of information.

Power meters can track the energy used by an entire building (standard utility meters), the energy used by a circuit on a building's electrical panel (such as a lighting or process circuit), or by a specific electrical appliance (such as a motor or a chiller). These meters usually involve current transformers, potential transformers, and some form of logic to calculate power demand or power usage.

An increasingly useful type of power meter is the interval meter. These meters measure electrical demand (usually measured in kilowatts) over a short period, such as every 15 minutes to match utility billing intervals.

Data Collection Systems

Data from advanced meters should be collected so it can be stored for analysis later. Automated Meter Reading (AMR) systems that collect data from advanced meters have become more sophisticated and more reliable.

Data from advanced power meters can be transferred automatically using:

- Phone modems
- Local area networks
- Building Automation Systems (BAS)
- Radio frequency transmissions (wireless networks)
- Powerline carriers

The choice of an AMR system will depend on the available infrastructure, the type of data collected, the financial resources available, the remoteness of the facility, and other considerations.

Data Storage and Retrieval Systems

The type and amount of data retrieved from advanced meters help determine the type of data storage and retrieval system that will be needed.

Long-term studies of energy usage will require storing data over longer periods than studies of daily energy usage.

Uses of Advanced Metering Data

Advanced metering data can help facility managers as they:

- Develop plans for energy conservation
- Analyze historical energy usage
- Evaluate equipment and processes (figure 3)
- Perform energy audits
- Evaluate process alternatives
- Evaluate equipment alternatives
- Review utility rate schedules with new equipment and processes
- Consider alternative energy suppliers
- Identify cogeneration opportunities
- Develop plans for measuring and verifying energy savings

Managers of facilities that are distributed geographically may benefit from an advanced metering system that allows the managers to use the Internet to view and record energy usage at all of their facilities. The system can be designed to collect, analyze, and present data describing an agency's energy usage and its progress toward meeting goals set by legislation, Executive order, or agency direction.

Building-level energy use reports can be provided to building managers and their staffs, as well as to tenants or occupants, helping them reduce energy usage as they become more aware of energy usage. For instance, heating and cooling could be set to kick on for fewer hours each day (figure 4).

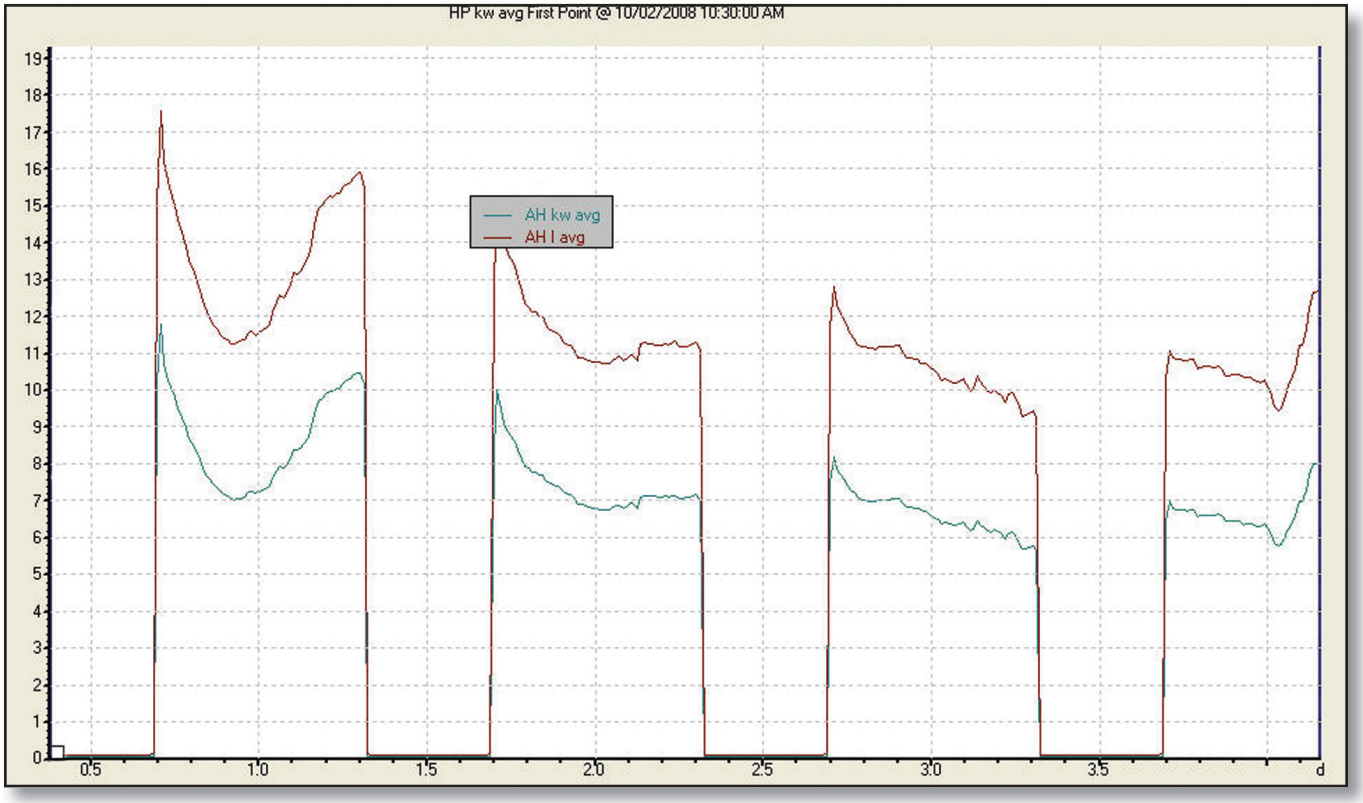

Figure 3—A typical log showing power usage as measured in kilowatts (kW) and current (I) for the air handler (AH) circuit at a Forest Service office. The Y-axis is power in kilowatts. The X-axis is days. The air handler is off during the evenings and uses the most power during the morning.

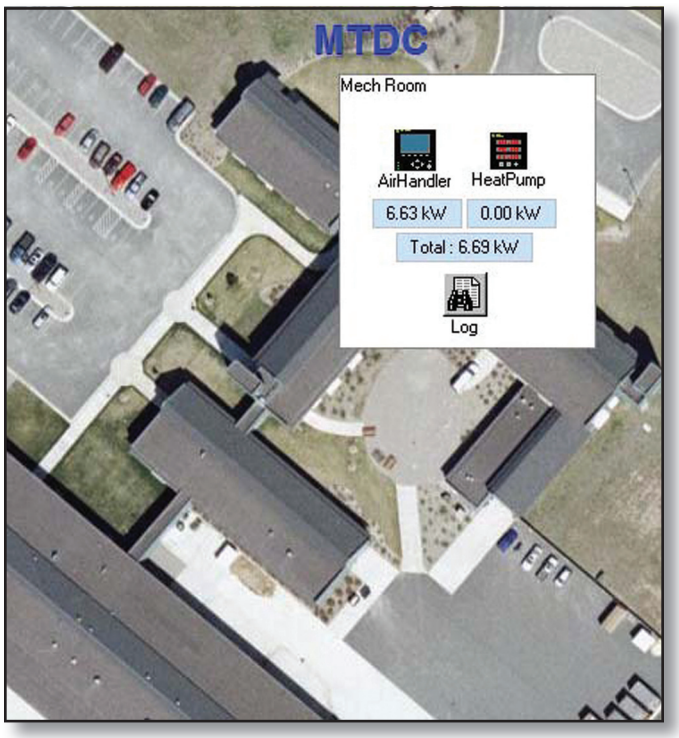

Figure 4—A computer screen shot of an advanced power meter's display with the inset window displaying the data being recorded. The user can select a background photo for the display (here an aerial view of MTDC) and the icons that represent the circuits being monitored.

Long-Term Monitoring

Long-term monitoring (*http://www1.eere.energy.gov/femp/pdfs/adv_metering.pdf*) will help facility managers meet the requirements of the Energy Policy Act of 2005. Advanced metering systems can record energy usage for long periods, even indefinitely. Usually, energy usage is metered for a whole building, although usage may be metered at the subcircuit level if the data would serve a particular benefit, such as monitoring a tenant's power consumption.

Long-term monitoring has several advantages. First, it provides data of the highest accuracy—quantifying both the magnitude and duration of energy usage. Second, a well-designed system can capture the most variance in the data.

The disadvantages of long-term monitoring include the cost and difficulty of installing and monitoring the equipment needed to store the data. Also, these systems need to be operated for a long enough time to produce usable results.

Long-term monitoring is particularly useful when the system is influenced by changes in weather, patterns of use, or other changes in operating conditions. In most cases, a network connection, phone modem, or the Internet is used to transmit data from the advanced meter to a central office.

Although many utility companies track energy usage and will compare current usage to recorded usage from the previous year, information available from long-term monitoring systems provides more detailed data, often of higher quality.

Choosing Advanced Metering Software and Hardware

Choosing metering software and hardware depends on reporting requirements, the specific features needed, the server's location, and software maintenance.

Reporting Requirements

Reporting software needs to poll meters daily for logged data; meters should be programmed to log the average and extreme values of measured parameters, such as line voltage and current, every 15 minutes.

Reports should display logged data from each of the system's meters for the following parameters:

- Line voltage for each circuit
- Line current for each circuit
- Total harmonic distortion (THD) for each circuit
- Real power for each circuit
- Reactive power or power factor for each circuit
- Line voltage sags or swells outside tolerances
- Aggregated power per meter
- Aggregated power per building

The software should be able to display the recorded values of each of these parameters as a graph. The user should be able to zoom into a specific timeframe within the data, showing periods of interest in more detail. If the default interval for a graph is 30 days, the user should be able to change the interval to 7 days or 24 hours.

The reporting software should allow users to access reports over computer networks so they do not have to install licensed software just to review reports. The reporting software may have a limit restricting the maximum number of users allowed to view reports at one time. The software should be able to identify and record energy usage that is subject to utilities' peak demand charges. Power monitoring systems should be able to monitor gas and water meters in the future.

Recommended Features

The reporting software should allow users to create summary displays (often called dashboards) that give abbreviated status reports on power usage by region or for critical buildings. The primary feature of the summary display is to report parameters that need attention.

Server Location and Software Maintenance

The reporting software should be installed on a server that has access to the Forest Service's wide-area network (WAN) or Intranet. Data from all advanced power meters should be polled daily so agency employees will have timely reports.

The reporting software will require maintenance. Maintenance includes adding new meters to the software's database as meters are installed and adding reporting features as users' needs change.

Equipment Installed at MTDC

Several manufacturers, including General Electric Co., E-Mon, Itron Inc., and Wechsler Instruments, offer meters that meet the reporting requirements of the Forest Service. Many of these meters were considered before MTDC chose units to evaluate and recommend.

MTDC installed and evaluated four systems from two manufacturers:

- Electro Industries/GaugeTech (EIG)—Nexus 1250 Power Meter and Shark200 Meter
- Schneider Electric—Square D PowerLogic ION7550 and ION6200 Power and Energy Meters.

Table 1 shows the costs of the units installed at MTDC.

Table 1—Advanced meters installed and evaluated at MTDC.

Company	Model	Comment	Price (2008)
Electro Industries/ GaugeTech	Nexus 1250	Installed in Underwriters Laboratory box with specified options	$7,000
Electro Industries/ GaugeTech	Shark200	Installed in Underwriters Laboratory box with specified options	$3,500
Schneider Electric	Square D PowerLogic ION7550	Current transformers would cost an additional $480	$5,897
Schneider Electric	Square D PowerLogic ION6200	Current transformers would cost an additional $480	$1,261

By choosing both less expensive and more expensive units from both manufacturers, we were able to evaluate products that addressed a range of metering and data logging needs. The higher end models could be accessed by remote computers.

An advanced power meter should at least monitor a structure's primary electrical power feed from an electric utility. The meter must have enough memory to store power consumption and power quality data at regular intervals and must connect to networks that can send data to a central server where data are archived and reports can be generated.

One meter does not provide detailed information showing how power usage is distributed among lighting, heating and cooling, computing, electrical tools, and appliances. Submeters (figure 5) on specific circuits allow power usage to be monitored on those circuits, providing information that could be used to reduce power consumption.

Some models of advanced meters evaluated at MTDC could import and store data from a network of more than 10 submeters. While submeters cannot perform some of the more sophisticated power quality measurements, they can provide information to an advanced meter. The advanced meter allows power usage in the facility to be analyzed.

Figure 5—A typical low-end submeter that sends data to a high-end meter that stores the data.

Observations on Installing and Commissioning Meters at MTDC

Advanced power meters from several manufacturers, including those evaluated at MTDC, need to be mounted in a National Electrical Manufacturers Association (NEMA)-rated enclosure. These enclosures must also accommodate an assortment of safety devices, switches, and communications links. Many local building codes require that the components and wiring practices used in these integrated assemblies have Underwriters Laboratory (UL) certifications or meet National Fire Protection Association standards.

The availability of integrated packages that included the NEMA-rated enclosure (or the cost of designing enclosures) was a factor when MTDC chose advanced power meters to evaluate. Even though MTDC has a wiring plan for constructing an enclosure, there are significant advantages to using a preassembled, integrated enclosure.

Schneider Electric has integrated packages for an assortment of its advanced meters. Several distributors of Schneider Electric products will build the integrated assemblies and can install and commission them.

Similar assemblies have been designed for the EIG meters, but the assemblies MTDC viewed lacked some of the features found in Schneider Electric assemblies that make it relatively easy to connect the meter to the monitored circuits.

While Schneider Electric and EIG submeters cost between $1,000 and $2,500, NEMA enclosures with protection and communication circuits cost another $1,000 to $2,000. Installation by a licensed electrician would cost another $500 or so.

Commissioning the meters after installation is an additional expense. The cost of commissioning would vary based on:

- Verifying that the current transformers have the correct orientation and are matched to the proper phase voltages
- Programming the IP address in the meters that are connected to the Forest Service's internal computer networks and verifying that the meter is communicating with the remote computer
- Programming the meters to log the desired parameters and for the proper circuit configurations (3-phase, 2-phase, voltage per phase, size of the current transformer)
- Programming the advanced meter and verifying that it is communicating with submeters and peripherals

Performance of Advanced Power Meters Installed at MTDC

MTDC installed four power meters and evaluated their performance for more than a year. The reporting software for the EIG meters was installed on two desktop computers. The reporting software for the Schneider Electric meters was installed on one computer.

EIG's "Communicator EXT" software is licensed per computer. One computer can monitor all the EIG meters it can access over the network.

The "Communicator EXT" software allows users to view any or all of the data retrieved from the meter. This allows activity to be viewed for specific hours or days from files including several months of data.

While a "Communicator EXT Lite" software package is available free from EIG, the free version does not allow meters to be configured remotely or reports to be generated. The free version does provide snapshots of current activity and allows voltage and current waveforms to be viewed for the circuits being monitored.

Schneider Electric's "PowerLogic ION Enterprise" software is licensed for the number of meters that will be monitored. Rather than having application software installed on each computer that monitors the meters, ION Enterprise software is installed on a server. Any computer with access to the server can use a Web browser to log into the application and access reports for any or all meters.

Recommended Software

The PowerLogic ION Enterprise software met the polling and reporting needs for Forest Service installations. The software directly polls electrical meters and provides a report to anyone with a Web browser and access to the Forest Service's internal network. Two custom templates should be designed, one for Forest Service facility managers and another for a Forest Service energy manager.

About the Authors

Ted Etter joined MTDC in 2002 as an electronics engineer and project leader. He has 20 years of experience designing test equipment, display devices, and medical instrumentation for private industry. For 6 years before joining MTDC, Etter taught courses in the electronics technology program at the University of Montana College of Technology, Missoula, MT. His work at MTDC includes projects in wireless communications, alternative energy sources, instrumentation, and process control. Etter received a bachelor's degree in mathematics from the University of Oregon and a master's degree in teacher education from Eastern Oregon State University.

Dick Karsky has been program leader for forest health protection, global positioning systems, and the air portion of the watershed, soil, and air program since the fall of 1999. Karsky has been a project leader at MTDC in global positioning systems, range, cooperative forestry, engineering, fire, reforestation and nurseries, residues, recreation, and forest health protection. He received a bachelor's degree in agricultural engineering from North Dakota State University and a master's degree in agricultural engineering from the University of Minnesota. He worked for private industry before coming to MTDC in 1977. In 2009, Karsky was named the Forest Service's Technical Engineer of the Year.

Steve Sichau is the regional design team electrical engineer/project manager for the Pacific Northwest Region. He provides electrical engineering assistance to forests in the region for contract administration, code questions, construction, power, lighting, power quality analysis, lightning protection, and other systems. Sichau has a bachelor's degree in electrical engineering from Oregon State University and completed a year's graduate study in solid state physics there. From 1971 to 2006, Sichau was the Pacific Northwest Region regional engineer.

Theron Miller received his Ph.D. in Forestry from the University of Montana in 1997 with an emphasis in natural resources social science. After graduating, he was a research and teaching professor at the University of Montana where his area of focus was applied social sciences directly related to management of natural resources on public lands. Miller joined MTDC in 2006 and is assisting with projects in safety and health, recreation, and fire and aviation management.

Andrew D. McLean joined MTDC in 2001 as an information technology trainee. Over the next 4 years he worked as assistant to the systems administrator, providing desktop and server support for the center. After McLean graduated from the University of Montana with a bachelor's degree in network management in 2005, he moved into his current position as program analyst. He provides technical support to a number of programs at the center and serves as the point of contact for all computer and server-related issues. He prepared the "Defensive Horse Safety" training course and has written articles for T&D News.

Library Card

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The Energy Policy Act of 2005 requires advanced meters to be installed in all Federal buildings by 2012. The Forest Service will require advanced meters and advanced metering systems to be installed in buildings larger than 10,000 gross square feet. The goal is for facility managers to use data collected by the advanced meters to identify opportunities for energy savings. The Missoula Technology and Development Center installed and evaluated a low-cost meter and a more expensive meter made by each of two different manufacturers: Electro Industries/GaugeTech (Shark200 and Nexus 1250) and Schneider Electric (Square D PowerLogic ION7550 and ION6200). MTDC recommends that the Forest Service use the PowerLogic ION Enterprise software, which allows persons to use a Web browser when viewing data collected by advanced meters.

Additional information about advanced metering is available for Forest Service and Bureau of Land Management employees only at <http://fsweb.mtdc.wo.fs.fed.us/programs/facilities/>.

Keywords: electricity, Electro Industries/GaugeTech, energy conservation, Energy Policy Act of 2005, Schneider Electric, specifications, Square D

Additional single copies of this document may be ordered from:

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