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# METERING PLAN

## Monitoring Energy and Potable Water Use in PNNL EMS4 Buildings

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# INTRODUCTION

Pacific Northwest National Laboratory (PNNL; Laboratory) has established a Sustainability Maintenance and Operations (M&O) Program with three key deliverables:

- » The contractually required (Clause H-43) Site Sustainability Plan (SSP)
- » The Laboratory Performance Evaluation and Measurement Plan (PEMP)
- » To establish goals, collect data, and report progress to meet the deliverables outlined in the annual Facilities and Operations (F&O) Business Plan.

The PNNL Metering Program operates within the Sustainability M&O Program and collects data, provides analysis, and makes recommendations in support of two of these deliverables: the SSP and the F&O Business Plan.

This 2012 edition of the annual Metering Plan conveys the vision of the recently reorganized PNNL Metering Program. It will present our progress toward the metering goals shared by all national laboratories and discuss PNNL’s contemporary approach to the installation of new meters. Perhaps most importantly, this Plan discusses the data analysis techniques with which PNNL is working to mature using the endless

streams of data newly available as a result of increased meter deployment over the last several years. Previous PNNL Metering Plans (Olson 2007; Olson, Berman, and Schielke 2008, 2009, and 2010; Pope et al. 2011) have documented specific meter connection schemes as the Laboratory focused on deploying meters in a first step towards managing energy use. This year’s Plan serves not only as a report on how far PNNL has come, but also as the beginning of a guideline on meter installation and data analysis that we intend to develop over time.

At PNNL, our **mission** is to transform the world through courageous discovery and Innovation. Our *Vision* is for our science and technology to inspire and enable the world to live prosperously, safely, and securely. Our **values** of integrity, creativity, collaboration, impact, and courage provide the foundation for all we do.

## OUR SUSTAINABILITY VISION

PNNL will be recognized as a **THOUGHT LEADER** in sustainability by our customers, our employees, and the community.

Our solutions, which **BALANCE** environmental, social, and economic forces, will be sought out and used to make the world a more sustainable place.

Every employee is **EMPOWERED** to improve our sustainability performance and enables us to achieve our ambitious sustainability goals.

# ADVANCED METERING PLAN

## VISION

The Sustainable M&O Program has three pillar areas that are the driving factors for implementing PNNL's Sustainability Program: environmental stewardship, social responsibility, and economic prosperity. The PNNL Metering Program works in support of the first pillar, environmental stewardship, specifically to reduce building energy use and greenhouse gas emissions and to minimize water use. The foundation for the Metering Program is our core goal set, which consists of four objectives:

- » Provide accurate data without interruption. Data should be of sufficient quality, quantity, and timeliness to enable effective analysis and support real-time commissioning.
- » Analyze data while it is still "fresh." Data analyses and the resulting recommendations are most relevant when real-time data is used.

- » Provide actionable recommendations to operations management.
- » Ensure PNNL's compliance with legislated metering requirements.

These core objectives guide the decisions that we make during annual planning and as we operate throughout the year. Additionally, the metering program works to enable the Intelligent Facilities and Infrastructure Strategy, a key objective of the Sustainability Program. The Metering Program supports three of the six fundamentals of the Intelligent Facilities and Infrastructure Strategy:

- » **Actionable Intelligence:** The lifeblood of building and process analysis is the metered data feeding it.
- » **Measurable Performance:** Metered data is used to verify energy savings measures are implemented correctly and to quantify savings over time.

- » **Consistent and Efficient Processes:** Continuous analysis of processes uses real-time metered data compared against accepted baselines to discover when a process begins to wander from its desired efficiency.




**PNNL  
Sustainability**





Much like a honeycomb with its interlocking pieces that gain strength through mutual support and integration—our three pillars and twelve priorities create a sustainability program that is greater than the sum of its parts. This is our triple bottom line.

## GOAL PROGRESS

A key metric used to gauge the progress of meter installations at PNNL is our progress toward the fourth Metering Program objective: *Ensure PNNL's compliance with legislated metering requirements*. Our Metering Program has made this goal a priority and has taken a leadership stance by completing the goal ahead of the requirement schedule for the three services below: electricity, natural gas, and water.

 The Energy Policy Act of 2005 (EPAct 2005) Section 103 requires that all federal buildings to install advanced electric metering systems where practicable by October 1, 2012. **PNNL has met this requirement, installing whole building advanced electric meters in 24 buildings.**

 The Energy Independence and Security Act of 2007 (EISA 2007) and the National Energy Conservation Policy Act require all federal buildings be metered for natural gas where cost effective by October 1, 2016. **PNNL has met this requirement, installing whole building advanced natural gas meters at 11 buildings.**

 EISA 2007 encourages metering water as a way to validate savings made as part of the water intensity reduction goals in the Act. **PNNL has placed a high priority on metering water down to the building level and has completed the water meter installation portfolio with advanced or standard meters (Table 1).**

### Table 1. Advanced Meter Technologies for PNNL EMS4 Buildings

| Building  | Building ID  | Building Square Footage (ft²) | Electrical Meter | Gas Meter | Water Meter Schedule |
|---|--------------|-------------------------------|------------------|-----------|----------------------|
| Environmental Molecular Science Laboratory                      | 3020         | 224,463                       | Advanced         | Advanced  | Advanced             |
| Radiological Calibrations Lab                                   | 318          | 37,025                        | Advanced         | Advanced  | Advanced             |
| Radiochemical Processing Laboratory                             | 325          | 144,820                       | Advanced         | Advanced  | Advanced             |
| Life Sciences Lab   | 331          | 115,127                       | Advanced         | Advanced  | Advanced             |
| Plant Operations & Maintenance Facility                         | 350          | 22,048                        | Advanced         | N/A       | Advanced             |
| Material Sciences & Technology Laboratory                       | 3410         | 79,878                        | Advanced         | Advanced  | Advanced             |
| Radiation Detection Laboratory                                  | 3420         | 81,369                        | Advanced         | Advanced  | Advanced             |
| Ultra Low Background Counting Laboratory                        | 3425         | 7,418                         | Advanced         | Advanced  | Advanced             |
| Ultratrace Laboratory   | 3430         | 70,298                        | Advanced         | Advanced  | Advanced             |
| Large Detector Laboratory                                       | 3440         | 5,488                         | Advanced         | N/A       | Advanced             |
| Laboratory Support Warehouse                                    | LSW          | 20,092                        | Advanced         | Advanced  | Standard             |
| 2400 Stevens Office/Lab Building                                | 2400 Stevens | 99,626                        | Advanced         | N/A       | Standard             |
| Environmental Technology Building                               | ETB          | 100,358                       | Advanced         | N/A       | Standard             |
| Information Sciences Building – 1                               | ISB I        | 50,200                        | Advanced         | N/A       | Standard             |
| Information Sciences Building – 2                               | ISB II       | 60,080                        | Advanced         | N/A       | Standard             |
| Laboratory Support Building                                     | LSB          | 83,921                        | Advanced         | N/A       | Standard             |
| National Security Building                                      | NSB          | 100,358                       | Advanced         | N/A       | Standard             |
| Sigma 1 Office Building   | Sigma I      | 20,000                        | Advanced         | N/A       | Standard             |
| Sigma 2 Office Building   | Sigma II     | 20,100                        | Advanced         | N/A       | Standard             |
| Sigma 3 Office Building   | Sigma III    | 20,090                        | Advanced         | N/A       | Standard             |
| Sigma 4 Office Building   | Sigma IV     | 20,530                        | Advanced         | N/A       | Standard             |
| Sigma 5 Office/Laboratory Building                              | Sigma V      | 47,900                        | Advanced         | Standard  | Standard             |
| Biological Sciences Facility                                    | BSF          | 78,218                        | Advanced         | Advanced  | Advanced             |
| Computational Sciences Facility                                 | CSF          | 65,861                        | Advanced         | Advanced  | Advanced             |
| Total EMS4 Facility Square Footage Suitable for Advanced Meters |              | 1,575,268                     |                  |           |                      |
| Total EMS4 Facilities   |              | 1,641,695                     |                  |           |                      |
| Percent EMS4 Facility Square Footage with Advanced Meters       |              | 96%                           |                  |           |                      |

As shown in the table, 96 percent of PNNL EMS4 facility square footage resides in a building where we opted to install advanced metering. Decisions to install advanced metering were made using the cost justification methodology introduced in the FEMP Metering Best Practices Guide and discussed in the following section.

## IMPLEMENTATION

PNNL’s Metering Program uses all four generic approaches to metering across the campus. Because of our commitment to metering as a key component of the Sustainability Program, we typically focus on long-term metering. We still evaluate installations on a case-by-case basis and are keenly aware of the costs and returned benefits from metering. As a result, we are equipped to deploy any of the four basic approaches for electrical metering based on specific need.

- » **One time/spot measurement:** Achieved through measurement by an electrically trained and qualified craftsman. Used to meter equipment where the current draw does not typically modulate and a single measurement is needed, typically as a consideration for a design project.
- » **Run-time measurement:** Achieved exclusively through our facility monitoring and control system. Run-time measurement is used as a diagnostic tool and also to alternate between motors on equipment where lead/lag settings are used in the control sequence to facilitating even wear.
- » **Short-term monitoring:** Used to quantify savings from a specific project when a permanent meter installation is not warranted. Most short-term monitoring is for the purpose of measuring electrical consumption. We typically use battery-powered HOBO meters by Onset to meet this

need. Examples include installing a temporary meter to baseline air compressor power for 30 days before a project to repair leaks in the distributed compressed air system throughout a building. At the conclusion of the project, the system is again monitored for 30 days to estimate savings as a result of the repairs. Likewise, we install a temporary meter on a lighting circuit before implementing advanced lighting control. This enables us to quantify savings and assists in commissioning the system because we can monitor how often the lights are off in the night when the building is unoccupied. This monitoring has alerted us to occupancy sensors installed in less than desirable locations, such as near air discharge registers, where false occupancy is detected.

- » **Long-term monitoring:** Our standard approach. Long-term monitoring provides valuable information in the short run but also allows trending over time, a primary input to our data analysis approach. PNNL collects data from long-term electric meters at the service for each building. Likewise, natural gas and water meters installed at the building entry are also long-term installations.

## DESIGN AND INSTALLATION

The metering program at PNNL employs a variety of meter types and technologies. Along with a cursory review of existing metering, new projects should begin design by working through the three questions as detailed below.

### *Do I need any additional meters to manage energy use?*

- » Proposed meter installation projects are evaluated against the cost justification methodology for simple payback detailed in the FEMP Metering Best Practices guide. The following formula is taken from the guidance:

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

- » This simple payback formula is used to determine if the return on investment of the meter installation is acceptable. While the formula provides us with an informative decision making tool, because each meter installation is evaluated separately, there are cases where a meter does not meet the threshold of practicality by the simple payback calculation and is still installed. This occurs if investigation reveals an opportunity for optimizing building or equipment operations where savings beyond costs for the service being metered can be realized.
- » Once it is determined that metering will be installed, the first tier is at the whole building level for electricity, natural gas, and water. Requirements behind whole building metering are detailed in the Goal Progress section, above. After ensuring that requirements for metering at the whole building level are met, consideration should be given to installing the sub-metering necessary to divide electrical consumption into four load categories: HVAC, IT, lighting, and miscellaneous plug load (discussed in the Data Analysis section). Further metering necessary for process optimization should be considered based on the scope of the project.

### *What meters should I use?*

- » Existing **electric meters** installed across the campus take on different characteristics due to the time period in which they were installed, design preferences, and project design constraints. Electric meter types installed include Veris, E-Mon, PQube, Square D, Cutler Hammer, Utility provider pulse, and others. New installations must be evaluated on a case-by-case basis given the design constraints.



- » On new switchboard installations, metering can be included as part of the manufactured package. For example, the Veris product line has proven robust and affordable for applications requiring retrofitting of existing equipment with metering. PNNL has installed hundreds of Veris Enercept meters to date. This meter has a compact design, no local display, and communicates directly with the Facilities Management Control System (FMCS). Recently, the new Veris E50 meter has been selected for several installations and is functioning well.
- » The Building Automation and Control network (BACnet) native E50 has a compact, local display and data logging capability. Separate meter power on the E50 has made it an attractive option for installations at equipment fed from two sources of power via a three-position transfer switch. PNNL is following an industry-wide trend to move towards control equipment that communicates using the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)-developed communications protocol standard. The primary benefit of selecting equipment that communicates using BACnet is its open protocol, allowing freedom from proprietary systems that limit future options.
- » In some applications, electric usage data for a specific piece of equipment can be obtained from a variable frequency drive or other installed component. When possible, we prefer to take advantage of existing metering or specify metering integral to a system being installed to keep project prices low.

- » The preferred **natural gas meter** used at PNNL is the Dattus by Itron. This solid-state meter uses fluidic oscillation technology and has data logging capabilities. Meters for natural gas tend to be the most costly to purchase and install.
- » PNNL employs several technologies of **water meters** across the campus. The most accurate (and most costly) to purchase and install is the compound meter, which combines a disc meter and a turbo meter in a single body. The Badger Compound Series is installed at several buildings and has proven to work well. Because of the ease of installation and low cost, the insertion turbine meter is an attractive, effective option. The Onicon 1100 and 1200 series meters offer an alternative to a full bore meter like the Badger Compound. Care must be taken during the design phase to ensure that minimum flows are met. Considerations can be taken, such as reducing the pipe diameter for a short section to increase fluid velocity across the meter. An additional benefit of the insertion turbine meter is the ability to “hot tap” an in-service line, eliminating the need for a system outage.

***How do I link these meters to the appropriate data collection systems?***

- » Most of the electric meters installed communicate to the Johnson Controls Metasys FMCS. The preferred method of communication for electric meters is BACnet standard communication protocol. Communication can also be accomplished using the JCI N2 communication protocol or a meter pulse output collected on an accumulator

point within the Metasys system, with translators that take proprietary communication protocols and translate them to an option compatible with the JCI system. Metered data is stored and trended and can be accessed using the Metasys server. PNNL also employs stand-alone advanced electric meters that store data that can be accessed directly either through a phone line or network connection. Data from meters not connected to the FMCS are retrieved by DSOM, which also has the ability to gather FMCS data.

- » Most gas meters, including all those employed at PNNL, use a pulse output from the meter collected on an accumulator point within the FMCS. This is a reliable, relatively simple way to collect data from the meter. The Dattus meters also log information that can be retrieved locally with a laptop and feature a local dial display.
- » PNNL has worked with the main water purveyor on the campus to retrofit some existing Badger water meter recorders with a pulse output module allowing data to be accumulated by the FMCS for real-time data without installing a separate meter in some locations. Most of the insertion turbine meters also offer a pulse output, with each pulse accounting for a stated number of gallons measured at the meter. Insertion turbine meters are also available with an analog output of 4-20 mA or 1-10VDC and measure water velocity or flow rate.
- » The guidelines above are used to select meters on a case-by-case basis. Additional considerations for new installations include the availability of existing infrastructure, space constraints, and consistency with other meters within a building.



# DATA ANALYSIS

The importance of data analysis within the PNNL metering program cannot be overstated and is the cornerstone for three of the program’s four core goals. In performing data analysis, the metering program seeks to achieve the following four objectives roughly based on the Office of Energy Efficiency, Natural Resources Canada (Hooke, Landry, and Hart 2009):

## Break down energy use and cost

- » Breaking down energy costs provides an increased awareness of where energy is being used across the lab and what utilities and areas are the highest consumers. Targeting heavy users offers an opportunity for larger savings with the same percentage reduction than a smaller user. Graphics are the best way to illustrate the division of use and cost. In addition to being a valuable analysis tool, energy use and cost graphics are used to increase understanding and awareness among laboratory employees.
- » Currently, the total energy use at PNNL is broken down by building for electricity and gas. As the metering program matures and submeters are installed, our goal is to create a load profile for each building that will divide electricity use into four subsystems: HVAC, IT, lighting, and plug load.

## Calculate performance levels

- » To compare our buildings and processes against other buildings and processes, industry standards, or the same buildings and processes from an earlier period, we calculate performance levels. These can be simple such as kW per square foot for an entire building or more detailed such as

coefficient of performance (COP) for a refrigeration system, boiler efficiency, or power utilization efficiency (PUE) of a data center.

## Understand the reasons for variable energy use and performance

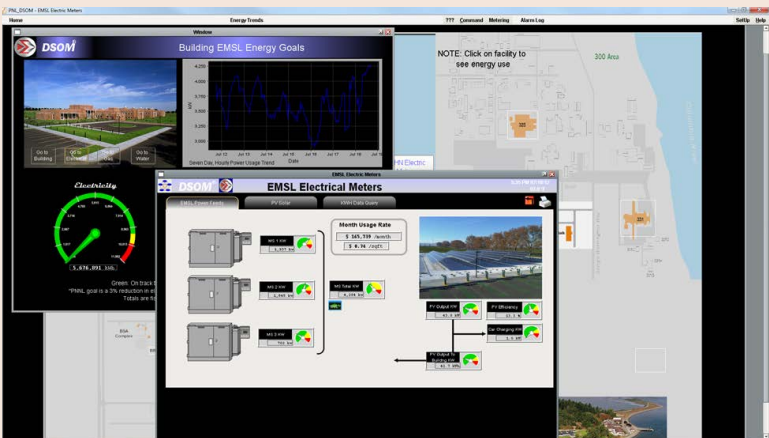
- » Energy use and performance levels can vary based on factors outside of our control, such as weather. The goal of our analysis is to understand the reasons for the variability and to identify parameters within our control that can improve performance and reduce energy use. Understanding the load profile for a building as a division of base load, weather load, and variable load can assist in this analysis. Using metered data and analysis techniques, we are working to establish optimum settings for HVAC equipment in various weather conditions. An example of high variability in performance levels is the COP in chiller plants at different loads.

## Track progress towards energy use targets and identify poor performance

- » As a national laboratory within the U.S. Department of Energy (DOE), our energy and water use target is clearly defined. DOE Order 430.2B (DOE 2008) requires reducing energy intensity by at least 30 percent by 2015 compared to a 2003 baseline. It also requires reducing potable water use by at least 16 percent by 2015 compared to a 2007 baseline. In addition to comparing current energy and water use to our mandated reduction goal, we also compare with historical data trended and archived within our FMCS system. Most commonly, we will compare observed use with an earlier

period such as the previous month or the same month from a previous year.

# DSOM



DSOM front page, dashboard, and electrical summary for Environmental Molecular Science Laboratory

To aid in data analysis, graphical presentation, and data storage, PNNL utilizes the Decision Support for Operations and Maintenance (DSOM) tool. Developed by PNNL, the DSOM system is an advanced supervision and diagnostic tool to reduce plant operating and maintenance costs and extend plant life.

Linking plant operators, maintenance staff, engineers, and administrators in one enterprise-wide system, DSOM combines online condition monitoring and control of equipment with unique diagnostic routines. Originally created for efficient operation of nuclear power plants, the science at the core of DSOM has been adapted cost effectively to meet the needs

of industrial processes, including power plants, continuous industrial processes plus facility plants, HVAC systems, and today’s metering.

DSOM is built around the concept of condition-based management. DSOM’s diagnostic capabilities prompt operators to make changes to keep systems operating at peak performance and avoid degradation and failures. It has been successfully integrated with standard sensor technology plus more advanced systems like vibration monitoring, laser systems, ultrasonic monitoring system, and utility meter plus submetering.

Field experience has validated that cost reductions of 20 to 40% can be realized through improved process efficiency, reduced O&M workload, reduced maintenance parts and labor, reduced energy consumption, and equipment life extension.

DSOM is now being integrated into the PNNL daily operations and tracking of energy goals.



DSOM dashboard for Radiochemical Processing Laboratory

BOCC

PNNL’s data analysis efforts are being consolidated around the recently constructed Building Operations Control Center (BOCC). The function of the BOCC is to reduce operational costs and optimize operations resulting in higher customer satisfaction and increased sustainable performance. The BOCC ensures that systems are off when not in use and are performing when needed at the utmost efficiency matched to meet mission demand and occupant comfort.

Inside the BOCC, staff are linking real-time monitoring with analytics to optimize energy, extend asset life, and enhance the reliability and efficiency of facility operations.

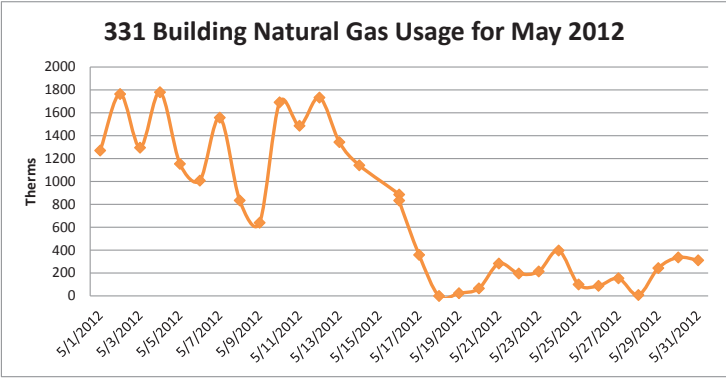
To reduce energy consumption effectively and ensure optimum performance, it is important to monitor and analyze real-time consumption versus demand. The BOCC is leveraging this data from the Johnson Controls Metasys system and in-house developed R&D software DSOM to perform diagnostics, trending, and analytics in a centralized command center. As facilities become more intelligent, the BOCC will be the hub between the operations, R&D, and infrastructure.



EXAMPLES

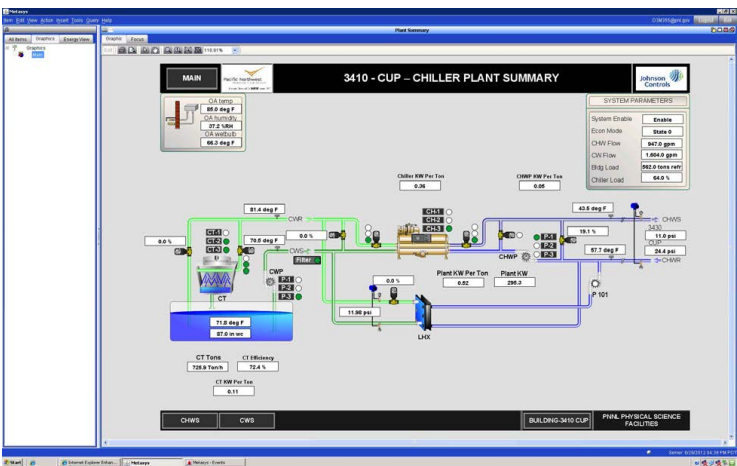
The following two examples highlight the confluence of metering, analysis, and the resulting recommendations. As the metering program matures, we hope that discoveries like the ones below will highlight the need for effective and dedicated energy management.

- » Metered gas data for the 331 building was analyzed in May 2012, and an unseasonable use rate was discovered. Field verification resulted in a steam leak being detected on a preheat heat exchanger and a unit heater. As a result of the investigation, valve positions were changed to isolate the leaks from the system. Meter data taken before and after the field remediation confirmed the reduced gas usage and is shown below. The estimated savings as a result of this action are 20 therms per hour or an annual savings of \$162,936.



- » As a result of analysis and observed operation in the field it was determined that the COP levels for the chiller plant at the recently constructed Physical Sciences Facility (PSF) are frequently outside desired levels. The unfavorable

COP levels are observed when the chiller plant is relatively unloaded in relation to one of the three 750-ton chillers. Differences in the design load of the plant and the load experienced after operating the facility for 2 years account for the low loading of the plant outside of peak cooling conditions. An engineering project is underway to redesign the plant and add a new, smaller chiller to service the buildings that make up the PSF during the low load conditions. Chiller plant summary screens like the ones below and the software behind them are used to calculate performance levels and provide a visual indication of parameters that fall outside expected values.



## PERSONNEL TRAINING

Metering technologies, the systems that aggregate the data, and the software that assists in data analysis are all rapidly advancing. As the nation steps up to face the energy challenge, our Laboratory practitioners must stay current and relevant.

In order to maintain that edge, the Sustainability Program promotes the following for its staff:

- » attending trade shows and vendor trainings
- » taking an active role in working groups within the industry
- » continuing education for FMCS technicians and engineers to maintain current working knowledge of the rapidly changing options and solutions for connecting new meter technologies to the existing and updating FMCS infrastructure
- » encouraging engineers to certify with industry professional peer groups such as the Certified Energy Manager (CEM) certification through the Association of Energy Engineers (AEE).

## FUNDING

Funding is necessary to maintain the metering program equipment and staff, data collection, analysis, and reporting activities. Funding for the metering program is established in the annual Sustainability Program budget. Key implementations are outlined in the Sustainability M&O Program description and are divided into three categories: people, systems, and processes. The Metering Program draws from two of these. Within the implementation category *people*, the metering program utilizes four key implementations: Sustainability subject matter experts (SMEs), Sustainability engineer, Facility Energy manager, and Utility Data Management specialist. Likewise, in the implementation category *systems*, the metering program feeds data into the FMCS. Funding to provide that data can be described in two ways: installation of strategic metering in support of goals and objectives; and maintenance, corrective actions, and upgrades for existing metering and data collection systems.

While priorities are established and funding is set on a fiscal year basis, PNNL's Sustainability Program maintains a nimble, agile approach. If unexpected opportunities arise during the year, the metering program remains poised to act and can adjust based on emerging needs.

## DATA

### Meter Data Validation

Once meters are installed, it is important to validate the resulting data. Meter data should go through an initial validation and then be checked periodically as part of an ongoing validation effort.

- » **Initial:** The initial performance validation of the meter involves comparing the meter data with billed data. Because billed data lags, the real-time metered data the validation of a new whole-building meter can take several months.
  - The absence of specific billed data for submeters (less than the whole building level) makes validation more difficult. Expected totals arrived at as a result of engineering calculations designed to allocate the whole building load to a more specific level are often used to compare with values yielded by submeters. Our experience with electric meter validation is that meters come correctly calibrated from the factory. Errors are almost exclusively attributed to an incorrect multiplier in the totalization phase, either by assuming an incorrect CT size or by assigning an incorrect pulse value.



» **Ongoing:** As we finish the installation phase of whole building metering we are looking towards the future and the best ongoing meter validation approach to pursue. While spot-checking has reassured us that our data collection is progressing well, we are planning to implement a meter performance validation strategy that will consist of an automated comparison of manually entered billed data with whole building data collected by our metering system.

### Portfolio Manager

PNNL makes use of the EPA's Portfolio Manager tool to track and assess energy and water consumption across the campus. Portfolio Manager has benchmarking tools and the ability to compare building energy performance with similar buildings off of the campus. Additional information on Portfolio Manager is available at [http://www.energystar.gov/index.cfm?c=evaluate\\_performance.bus\\_portfoliomanager](http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager).

### DATA RECOVERY

The backbone of our recovery plan is early detection when a data loss problem arises. Often data loss can be attributed to a disruption in the communication from the meter to the data collection system, usually Metasys or DSOM. Data recovery after a communication failure is made much simpler when advanced meters are installed with data logging capability. In the Federal Energy Management Program (FEMP) sponsored *Metering Best Practices, A Guide to Achieving Utility Resource Efficiency*, August 2011 (Sullivan, Pugh, and Hunt 2011),

advanced meters are defined as having the capability to measure and record interval data (at least hourly for electricity) and communicating the data to a remote location in a format that can be easily integrated into an advanced metering system, which includes data acquisition and analyses.

When a communication failure is discovered, efforts to restore the line should begin immediately. As some meters can be read locally with a laptop computer, this feature can be used to restore lost data sets manually, although it is time consuming. Meters that will cache data for a month or more and report after a failed communication line has been restored are preferred. It is also possible to use trend and historic data to fill in gaps on buildings where reporting is required, but our goal is accurate, timely information.

## CONCLUSION

The PNNL Metering Program has experienced success in meeting the whole building advanced metering goals. As meter installations continue, data analysis and data organization move to the forefront in our effort to reduce energy consumption. Over the next year, the Metering Program will strive to meet the reduction challenge, in part by meeting these milestones:

» PNNL Sustainability Program personnel will conduct weekly Energy and Optimization meetings with each core team to discuss energy use trends and help identify building tuning

opportunities. Currently, these meetings use a combination of utility billing data and real-time metered data. A milestone for the energy program will be for these energy meetings to use metered data exclusively in the discussions, with billed data used only for ongoing meter validation efforts.

- » Build load profiles for key buildings that divide building electrical consumption into four subsystem categories: HVAC, IT, lighting and miscellaneous plug load.
- » Build load profiles for key buildings that divide building electrical consumption into three building load types: base load, variable load, and weather load.
- » Enhance the existing analysis tools to automate examination of load profiles, comparing expected profiles with actual metered data and alerting our energy management team when results are outside of expected parameters.
- » Complete building dashboards and meter data interface system for all buildings in DSOM. Improving the usability and functionality within our meter data management tool will be the biggest step in getting metered data into the hands of practitioners across the Laboratory that can use the technology to make informed engineering decisions. For the metered data to have the greatest effect, it must be available to and used by a greater number of staff than the small data analysis team within the Sustainability Program.

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