Best Practices for Metering State Agency Campuses

January 14, 2015

This guide is intended for Washington State Agencies.

Special thanks to Greg Rock at Washington State Department of Commerce for the section on Computing Cost Effectiveness of Metering Systems, and many other substantial contributions to planning, organizing, researching and writing this guide. Thanks to the facilities directors and others who took the time to make suggestions and give advice from their experiences metering campuses, for the benefit of those who are considering metering. They are not responsible for any shortcomings of this guide: Bob Pasquariello, Steve Abercrombie, Michael Coffey, Larry Covey, Chuck Davis, Rich Davis, Jim Gilbert, Robert Hail, Jim Hayes, Barry Holldorf, Lonn Inman, Steve Kozlen, Ron Major, Mat Montagner, Jeremy Richmond, Pete Segall, Ian Siadak, Terry Stanford, Jim Taylor, Grant Thorsland, Tom Weisweaver, and Jack Wells, and others.

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Best Practices for Metering State Agency Campuses

Introduction

The 2009 Washington State Building Energy Benchmarking law (RCW 19.27A.190) requires state agencies to use Portfolio Manager to track the energy use of buildings. Many significant state agency buildings which are on campuses or compounds are not separately metered. Some agencies are now either metering, or considering metering their buildings to better manage energy use. This guideline is intended to provide basic guidance to agencies about how to meter buildings. Much of the advice and information in this report is from plant managers and engineers in Washington State with recent experience metering buildings on college or state agency campuses.

What is Building Energy Metering?

Throughout this report, "building energy metering" is collecting and monitoring all the energy used by a building at least monthly. A fully metered building will have a building energy meter for each type of energy the building uses.

For instance if a building is served by electricity, natural gas, and a chilled water loop, there will be a meter that records electricity use, a meter that records natural gas use, and a meter that records the amount of heat rejected to the chilled water. The installed metering system must include hardware and software that delivers energy data in a format that is easy to access and upload to Portfolio Manager, or it may upload the data automatically to Portfolio Manager. The focus of this report will be on best practices for building level metering of energy consumption.

Sustainability Advisor Ian Siadak, on why he is working with college staff to create a metering plan: "We have a poor grasp of our own resource use. Commissioning did not find all existing inefficiencies. We need to know which buildings are energy hogs and which are good performers, so we can identify best practices and use our resources more efficiently."

Why Meter Building Energy Use?

Building level metering is a tool that can help you identify energy waste and find opportunities for energy savings. Use meters to monitor the energy use of a building over time, to compare the energy use of similar buildings, and to track progress toward greenhouse gas or energy use reduction goals.

How to Use This Report

General advice about metering campuses is provided in this guideline. *Throughout this Guideline there are links to Appendices which provide more detailed technical information.*

Before Metering a Campus

Before you invest in metering, resolve to meet these three requirements for success:

1. **Collect and Record Energy Data Continuously**

   Energy data are most useful if collected and monitored regularly over a long period of time.

2. **Identify Energy Saving Opportunities**

   Use energy analysis tools to create reports of trends and comparisons. Review energy use reports with staff and building occupants, to work together toward energy reduction goals. Provide energy efficiency training to facilities staff. Regular meetings with maintenance supervisors, engineers and departmental leads work well to improve operations. Encourage facilities staff and building occupants to find energy saving opportunities.

3. **Take Action**

   Maximize dollar and energy savings from your investment in meters by resolving to act on the opportunities you find. At the time funds are approved for the metering system, get executive board and administration commitment to actively pursue and invest in energy saving operations and projects. Meters do not save energy – actions do!

Have an action plan. Decide what capabilities the energy management system will have. Commit to using the system to identify opportunities, and taking action to get the energy savings. Tools like fault detection and energy analytics are needed to find substantial energy savings. Staff time must be committed to monitoring and using the energy data.

Encourage budget managers to reinvest utility savings dollars in other projects that create more energy efficiency, and more utility savings.

Align your metering plans with 20-year facilities plans, and the agency goals and mission. Have a long term plan to maintain the metering and reporting system. *See Appendix 1 - Long Term Planning and Greenhouse Gas Emissions Limits. Also, see Appendix 2 – Operational Energy Saving Measures.*

Interim Measures that Don't Require Meters

While you are waiting for your metering system to be installed, there are interim energy saving measures you can implement which don't require meters. Consider obvious energy efficiency improvements such as replacing inefficient motors in pump stations, and replacing exterior lighting with LEDs. Do a comprehensive energy audit of your campuses or compounds. Re-commission existing buildings. Analyze your utility bills for accuracy. Engage building occupants in operational efficiency and energy conservation efforts. *See Appendix 2 - Operational Energy Saving Measures.*

Setting Project Scope

Scoping Campus or Compound Metering Requirements

Draw an imaginary boundary around the campus. Identify all the energy sources that cross the boundary into the campus. You may be able to measure all campus energy on existing utility meters. If your natural gas or electrical utility serves more than 25,000 customers, RCW

Steps to Metering a Campus or Compound

- Identify existing Utility meters and request automated benchmarking
- Using total campus energy costs, determine potential benefits of metering
- Create a metering plan aligned with the 20 year facilities plan and strategies to meet greenhouse gas reduction goals
- Identify funding sources
- Determine scope and budget of metering system installation project
- Choose public works delivery method
- Install metering system

19.27A.170 requires them to upload energy data into your Portfolio Manager account for you. If you get deliveries of propane or diesel fuel for heating buildings, or your utilities do not provide auto entry, consider working with your accounting department to create a process for entering energy quantities from the invoices into Portfolio Manager as part of the monthly bill pay process.

Scoping Building Metering Requirements

Determine the scope of metering for each of the buildings on your campus or compound. Draw an imaginary boundary around each building. Each of the energy sources that cross the boundary into the building will require a meter. Hardware and Information Technology (IT) infrastructure will be required to collect and transmit the energy data from the meters in the building to the metering system head end. Metering system software is required to make the energy data accessible and useful.

Buildings on large campuses with steam loops can be especially challenging to meter. To overcome the higher cost, meter the whole campus at once. Ensure that all significant buildings are metered – you will not be able to include buildings that use small amounts of steam. Install a system that is reliable and easy to maintain. Consider making a capital request or rolling the metering project into an ESPC project.

General Principles to Help You Decide What Buildings to Meter:

- Meter the buildings that are the largest, and use the most energy.
- Use the 80/20 rule – measure the majority of your energy use, which is most affordable to meter.
- If you estimate that a building uses more than $5000 of energy a year, it may be worth metering.
- For buildings that require more expensive BTU meters, estimate how much energy you may save each year if you carefully monitor the building's energy use, and multiply by how many years you are willing to take to recover your investment. Can you meter the building with that budget?
- Some loads such as unheated sheds or utility pumping stations will be too small to meter cost effectively. It is good practice to compare the sum of energy use from building meters to the sum of energy use from campus utility meters. If the difference is significant, consider whether you have large unmetered loads which should be metered, or whether there is an error in the data.
- Look at whole campus energy use when determining budget and benefits, and deciding what to meter. This may make it affordable to include some higher cost BTU meters in a metering project.
- Strive for a campus metering system that conveniently reports the Energy Use Intensity (EUI) of each significant building.
- When calculating the costs of the metering system, remember to include repairs, calibration, and other operational and administrative time.

Choosing Meters and Making System Choices

Here are a few basic questions to ask to guide choices and to prepare for directing the design consultant:

- Why am I metering? What is the purpose of this meter? (e.g., to charge occupants for energy use, to report monthly building energy use in Portfolio Manager, to collect 15 minute data for troubleshooting system performance). What kind of meter do I need for these functions?
- How will I collect and access the data from this meter? How to integrate into the DDC system? How to store the data? How to access it? How to make the data readable and usable?
- Do I want the meter data to upload automatically to Portfolio Manager?
- What will I do with this system in the future? Do I want to submeter? Demand control? Energy analytics? Fault detection?

Controls systems and software have a short life, possibly 15 years. Changing technology makes it difficult to plan beyond that. To avoid choosing a system that limits your options, identify the features you will add, and include them immediately to begin saving energy without delay. Ensure that your meter equipment and interface system use a common communication language that has significant market traction (BacNet or ModBus). Consider meters and components that can collect 15 minute data for the most recent month, for troubleshooting and energy analytics. Consider storage and software that make it easy to see anomalies and compare one day, week or year to another with user-friendly graphs and trends. Ask the system designer if you will have the option of adding demand control in the future.

See Appendix 3 -- Energy Information Systems for more information on data collection and analysis, and controls system features.

Measuring the Energy Entering the Building

Choose consumption meters to reliably collect energy data for each building, rather than calculating building energy use from data points in the building controls system. A consumption meter is like an odometer. If it gets disconnected, it remembers the cumulative energy use. This is good for reliable building energy use collection.

Electrical meters: Solid state digital electrical meters are accurate and require little maintenance. Ask your controls system vendor which electrical meters communicate well with your controls system, and what meter features to choose. Relatively inexpensive electrical meters may be sufficient to monitor whole building electrical use.

Natural gas meters: Selection of a natural gas meter requires consideration of many factors by an experienced design consultant. Choosing the wrong natural gas meter for an application can be a costly mistake. The table below is a starting point for discussions with your project engineer:

Table 1. Common Natural Gas Metering Technologies and Key Criteria

Criteria	Positive Displacement	Orifice	Venturi	Annubar	Turbine	Vortex Shedding
Accuracy	Good	Moderate	Good	Good	Good	Good
Repeatability (Precision)	Good	Good	Good	Very Good	Low	Very Good
Turndown Ratio	10:01	<5:1	< 5:1	10:01	10:01	20:01
Installation Ease	Easy	Easy	Moderate	Easy	Challenging	Moderate
Pressure loss	Medium	Moderate	Low	Low	Moderate	Low
Recalibration Needs	Infrequent	Frequent	Infrequent	Infrequent	Frequent	Infrequent
Capital Cost	Low	Low	Moderate	Low	Moderate	Moderate
Installed Cost	Moderate	Low	Moderate	Low	Moderate	Moderate
Maintenance Cost	Low	High	Moderate	Low	Moderate	Low

Adapted from Metering Best Practices: A Guide to Achieving Utility Resource Efficiency, Release 2.0, August 2011, US Dept of Energy, EERE, Federal Energy Management Program (FEMP), page 107. Available at: http://www1.eere.energy.gov/femp/pdfs/mbpg.pdf

When adding natural gas service for a new building, you must decide whether to extend an existing gas line, or ask the natural gas utility to install a utility grade meter. The utility is responsible for maintenance and risk of explosion up to the meter. In some cases, the natural gas utility may not be willing to take responsibility for gas lines to buildings on a campus. Disadvantages of a utility meter include higher installation cost, higher rates for disaggregated loads, and monthly fees. Advantages of a utility meter include avoided maintenance cost, avoided risk, and automated uploading of data into Portfolio Manager by the utility. Customer owned buried natural gas piping may be subject to "master meter" regulations under the Washington Utilities and Transportation Commission, the WUTC.

Chilled Water or Hot Water: For measuring chilled water or hot water from a campus loop, the most effective choice may be an ultrasonic BTU meter that measures flow and temperature. Ask the project engineer to discuss your options with you. A consumption meter is likely more accurate than collecting data from building controls.

Steam: For measuring steam from a campus loop, a BTU meter on the hot water side of the heat exchanger may be the least expensive and most accurate option. Ask the project engineer to discuss this alternative to steam meters with you. Choose a meter that will measure the heat entering the building.

Here are common types of meters capable of measuring steam:

- Steam meter – Expensive, reads actual steam use accurately within a given range, can't read low flows so it can't read shoulder season or summer usage accurately, energy efficiency improvements can reduce steam flow to below the meter's range.
- Condensate meter – Better for measuring variable steam flows, good for measuring average system performance, provides approximate building heat usage, data is tied loosely to when energy is used because it measures the condensate intermittently when the condensate pump runs. Measuring hot water is technically less difficult than measuring steam.
- BTU meter on the hot water side of the heat exchanger – This is the recommended way to measure steam. Use a strap-on ultrasonic meter that measures flow and temperature of the hot water. Using the building controls system to collect data from several devices to calculate flow and temperature is likely less accurate.

Campus Loops: It is good practice to measure the energy entering and leaving the campus steam plant, hot water plant or chilled water plant. Use these data to compute plant efficiency. Use the data on energy leaving the plant in combination with the sum of building energy use to compute energy losses in the campus loop and to verify the accuracy of your meters.

Selection of a steam meter requires consideration of many factors by an experienced design consultant. Choosing the wrong steam meter for an application can be a costly mistake. The table below is a starting point for discussions with your project engineer about selecting a steam meter:

Table 2. Selecting a Suitable Steam Flow Meter

Criteria	**Turbine**	**Rotary shunt**	**Orifice plate**	**Variable orifice**	**Spring loaded variable orifice**	**Pitot tube**	**Averaging Pitot tube**	**Vortex shedding**
Accuracy	Good	Moderate	Moderate	Good	Good	Good	Good	Good
Repeatability (Precision)	Poor	Poor	Good	Moderate	Good	Good	Very good	Very good
Sensitivity to vibration	Low	Low	Low	Moderate	Low	Low	Low	Poor
Sensitivity to installation	High	High	High/moderate	Low	Low	Moderate	Moderate	High/moderate
Installation ease	Difficult	Moderate	Easy	Moderate	Easy	Very easy	Very easy	Moderate
Pressure loss	Moderate	Moderate	Moderate	Low	Low to moderate	Low	Low	Low to moderate
Recalibration	Frequent	Frequent	Frequent	Frequent	Infrequent	Infrequent	Infrequent	Infrequent
Purchase cost	Moderate	High	Low	Moderate	Moderate	Low	Low	Moderate
Installed cost	Moderate	Moderate	Low	Moderate	Moderate	Low	Low	Moderate
Maintenance cost	Moderate	Moderate	High	Moderate	Moderate	Low	Low	Low

Adapted from Good Practice Guide: Reducing Energy Consumption Costs by Steam Metering, Carbon Trust, London, 2005. Available at: http://thecesh.com/wp-content/uploads/2010/05/GPG018.pdf

Information Technology (IT) Infrastructure: Until you have the system designer on board, it may be difficult to determine whether you have adequate campus IT infrastructure, and whether upgrades to controls systems will be desirable as part of your metering system. It is generally best to send the energy data from each building to a data controller with storage, then transfer the energy data from the data controller to an energy management software program in a single head-end for the entire campus. There must be adequate space to store the data, where it is accessible by maintenance staff. The information technology backbone that carries data through the campus must be robust, high capacity and reliable. Include your agency IT team in metering system project planning from the very beginning.

Compatibility and open protocol communications issues

- Strive to have one head end for all building controls throughout the campus. It is possible to use a single head end for controls from multiple vendors. Standardize on one controls system vendor to avoid submetering challenges caused by imperfect communication between meters and BacNet or LonWorks compliant proprietary equipment.
- Choose meters carefully. Ask your controls system vendor which meters work well with and communicate well with your controls system.
- Integrate your building controls with your meters to get the most functionality out of your controls and your meters.
- Always use open communications protocol (BacNet or ModBus).
- Work with the system designer to ensure that meter data is easily accessible under all conditions. For instance, all meter rollovers, where the accumulation exceeds the register capacity, should be base 10 numbers. Data should not be lost in power outages or modifications to controls.

Budgeting to Install Building Energy Meters

The main costs of your metering project will be: meters for every type of energy serving each significant building, upgrades to information technology infrastructure, and hardware and software to collect the energy data and make it accessible. *See Appendix 4 – Making a Business Case for Metering Systems.*

Table 3 shows the cost of recent metering system projects at public colleges in the State of Washington (there are more examples of metering campuses at colleges than state agencies):

Table 3. Examples of Metering System Scope and Cost (Recent Installations)

College name, and facilities contact information	Total annual campus energy bills	Number of campus buildings metered in this project	Total cost of campus metering project, including all soft costs and tax	Delivery method	Contractors and consultants	Meter types	How data is uploaded to Portfolio Manager	System features (submetering of building systems, 15 minute data, energy analytics software including user-friendly trends, demand control, fault detection, dashboards, or describe other)	Describe extent of DDC controls upgrades or IT infrastrucure improvements required to support metering system, which were included in the project cost	Other information about your system	Metering system cost per building
Pierce College Fort Steilacoom, Jim Taylor, Facilities Director, jtaylor@pierce.ctc.edu, 253-312-7267	$ 520,887	10	$ 208,000	Energy Savings Performance Contract	Ameresco, Johnson Controls	Elec and natural gas	Automatically uploads to Excel spreadsheet	15 minute data, energy analytics with trends	No significant added infrastructure or DDC costs	Some existing new buildings had meters, and there are some existing utility gas meters. This project also tied them in to the meter data collection system. Two BTU meters remain to be added.	$ 20,800
Pierce College Puyallup, Jim Taylor, Facilities Director, jtaylor@pierce.ctc.edu, 253-312-7267	$ 483,701	8	$ 127,000	Energy Savings Performance Contract	Ameresco, Johnson Controls	Elec and natural gas	Automatically uploads to Excel spreadsheet	15 minute data, energy analytics with trends	No significant added infrastructure or DDC costs	Some existing new buildings had meters, and there are some existing utility gas meters. This project also tied them in to the meter data collection system.	$ 15,875
Clover Park Tech College, Linda Schoonmaker, Todd Flynn DES PM	$ 857,268	19	$ 275,900	Energy Savings Performance Contract	Ameresco, ATS/Alerton	Elec and natural gas	Automatically uploads to Excel spreadsheet and Portfolio Manager	Skyspark analytics system, real time data, energy analytics with trends; no "public display" was included (i.e. public kiosk for graphical interface)	Infrastructure costs for network cabling, no significant added DDC costs	The costs include installation of 19 power meters and 11 gas meters; 1 existing power meter was integrated; one building is a remote campus several miles from main campus	$ 14,521
Highline College, Barry Holldorf Director of Faciilities and Operations bholldorf@highline.edu, 206-870-3793	$ 785,966	5	$ 32,000	Energy Savings Performance Contract	MacDonald Miller	Electrical only	Data reports out through Honeywell DDC	15 minute data, energy analytics with trends feed into our Iconics Dashboard	No significant added infrastructure or DDC costs	Continuing to install electrical meters on campus buildings with a goal to have a meter on each building over 5000 sq ft. (though we metered three additional bldgs. it required 5 submeters)	$ 6,400
Olympic College, Bob Pasquariello, 360-475-7835		11	$ 149,000	Energy Savings Performance Contract	Ameresco, Control Contractors Inc., C and C Solutions	Electric, BTU meters and natural gas	Automatically uploads to Excel spreadsheet	Real time energy and BTU data with trends; no "public display" was included (i.e. public kiosk for graphical interface)	Infrastructure costs for network cabling, no significant added DDC costs	The costs include installation of 9 power meters and 6 BTU meters; added pulse heads to 4 gas meters; installed Shark meters for power and Onicon BTU meters for hot water heat buildings; scope included 3 buildings at two remote campuses	$ 13,545

Planning and Budgeting to Maintain a Building Energy Metering System

Budget for ongoing maintenance and repair of metering systems, including meters, hardware and software. More than one or two people on the facilities staff should regularly use and operate the metering system, energy analytics and reporting software to ensure energy tracking is not interrupted by changes in staff.

Choose how you want to maintain your metering system:

- Subscription service – using a subscription service costs more, but may provide the data in a more usable form, and transfers responsibility for maintaining the energy management software to the service provider
- Hire a consultant to maintain the system for you – hiring a company that specializes in building energy management can be affordable, because it uses experienced people to do tasks that might otherwise take up more of your staff's time
- Do it yourself – requires highly qualified staff, and staff time. However, no one is better situated to identify and internalize energy-saving opportunities than on-site staff.

A well-designed system will save maintenance costs. Simple is better.

Finding Funds and Choosing Project Delivery Tools to Meter a Campus

Highline Community College used three different ways of funding and delivering metering: (1) capital funds using JOC, (2) a campus standard of installing meters with each renovation, and (3) a DES ESPC which rolled metering system installation into a building energy retrofit project funded by energy savings and grant funds:

- CONTACTS:
  - Highline Community College Contact: Barry Holldorf, 206-870-3793
  - Architect/Mechanical: McGranahan/Greenbush
  - JOC contact: Bershauer Phillips (DB Solutions, engineering)
  - ESCO contact: Jeremy Richmond, MacDonald-Miller
  - DES ESPC contact: Joe Sullivan, DES Energy
- Existing condition included electric meters on some buildings, and some natural gas and hot water metering. No existing sub-metering within buildings.
- **Started with $13k metering plan/study by McGranahan/Greenbush, which laid out electric, water, hot water heating, and natural gas metering. Study identified electrical panels and other basic details which became the outline for a Job Order Contract (JOC).**
- Contracted using JOC for a turnkey campus building metering project, which installed electrical meters only for buildings greater than 10,000 sf on the Highline campus. JOC delivery method was fast and effective.
- Subsequently used JOC to install a gas pulse meter on the 3 inch natural gas line to the boilers which provide hot water for heating to 4 large buildings still served by campus hot water. This was a requirement of the Puget Sound Clean Air Agency. Approximate cost about $33k.
- The college ran out of funds to do more metering at this point. **They continued to find a way to install meters with each building renovation project.**
- **A current DES ESPC project is installing 7 meters** in 5 more buildings (the 2 added meters were necessary to collect energy data to subtract, because some buildings had daisy-chained electrical service). Approximate cost for 7 meters was $40k. "**The ESPC project delivery method provided better prices, and a collaborative partnership with the ESCO to 'get it in right,'" says Facilities Director Barry Holldorf, "ESPC is the way to do it."**

There are future plans for 3-4 BTU meters to measure hot water from the hot water loop that provides heat for several large existing buildings. The college is using ICONICS software as a dashboard now, with plans for future options such as fault detection and load shedding.

Benefits of Energy Metering

The following table suggests energy savings ranges based on different uses for metered data:

Table 4. Energy Monitoring Savings Ranges

Action	Typical Savings
• Occupants engaged in reducing energy use. Facilities staff aware of monthly building energy use, trends, and goals.	2 to 5% (improved awareness)
• Occupants engaged in reducing energy use. Facilities staff aware of monthly building energy use, trends and goals. • Facilities staff actively striving to control and maintain the building to reduce energy use. They use meter data and information from the building controls system to pursue energy efficient operations.	5 to 15% (improved awareness and implementation of O&M improvements)
• Occupants engaged in reducing energy use. Facilities staff aware of monthly building energy use, trends and goals. • Facilities staff actively striving to control and maintain the building to reduce energy use. They use meter data and information from the building controls system to pursue energy efficient operations. • Management aware of building energy use on a monthly or more frequent basis. Management makes energy use reduction a part of the organizational mission. Management focuses attention on progress toward building energy use reduction goals, and is committed to investing in energy saving projects such as building energy retrofits.	15 – 45% (improved awareness, implementation of O&M improvements, energy use reduction incorporated into organizational mission, investment in energy saving projects, and continuing management attention)

*Adapted from "Guidance for Electric Metering in Federal Buildings," and revised for use by public facilities in Washington State. Available at: *https://www1.eere.energy.gov/femp/pdfs/adv_metering.pdf*

Using the table above, estimate the savings you will get, based on the actions you intend to take, the Energy Use Intensity (EUI) of your buildings, previous audits and retrofits of your buildings, and other practical considerations. Meters do not save energy. Actions save energy.

Other benefits of using metering systems to monitor energy use are more difficult to quantify. These include intermittent benefits from detecting leaks or spikes in energy use and possible maintenance benefits and longer equipment life from proactive maintenance using fault detection.

Other benefits of metering at Highline Community College

- Highline CC saved money on a recent permit application. Data from electrical meters was accepted by L&I as proof of load, making a separate load factor study unnecessary, saving engineering time and money.
- Highline used energy data to see an upward trend in gas usage after a boiler controls upgrade that was intended to save energy. The ESCO found and corrected the problem.
- Used energy data from meters to agree with the ESCO on a project energy use baseline.
- Used energy data from meters to find buildings with the highest energy use per square foot, and made sure the ESCO looked for energy saving measures in those buildings in the ESPC project.
- Maintenance staff uses energy analytics and a dashboard to see trends and anomalies. They use that information to take action.

"Build strong support for the project. Decide how to present the project to all the stakeholders as a suite of benefits to the college. Bring more supporters and participants to the table. Articulate the value of the project in many ways." – Ian Siadak, Seattle Colleges Sustainability Advisor, on a project for which faculty is considering the potential instructional value of energy analytics and dashboards.

Finding Funds and Proposing a Project to Management

Include metering systems in funding requests for new building projects and renovations. Consider campus metering systems when requesting funds to add to or renovate buildings or improve campus infrastructure. Metering can sometimes be funded using savings from other energy saving measures as part of a campus-wide or agency regional Energy Savings Performance Contracting project.

You can make a business case for borrowing funds to install a metering system (see Table 4 on page 12). Take care not to double-count savings from energy retrofit measures for which you may be borrowing. Emphasize that savings come from actions taken to save energy. (*See Appendix 3 – Making a Business Case for Metering Systems.)*

Benefits of Energy Monitoring Systems

- Identify poor performing buildings which may benefit from an energy audit and retrofit
- Quickly identify spikes in energy use or equipment failures that waste the most energy (fault detection)
- Verify utility savings generated from an energy saving project
- Benchmark building utility consumption
- Display building consumption data to drive behavioral changes
- Enable utility charge back to tenants to financially incentivize energy conservation
- Assist with obtaining LEED or ENERGY STAR certifications
- Reduce utility demand charges
- Improve occupant engagement and comfort

Building Metering Project Delivery Options

The Washington State Energy Code requires new buildings to be metered. Make sure new building projects or substantial building renovations incorporate new and existing meters into the campus metering system so you can conveniently access the data.

There are several delivery methods for installing metering systems in public buildings:

- Design Bid Build (DBB) – Most public works construction is delivered by Design Bid Build. Include metering systems in major renovations and new construction projects. Consider how to implement parts of the long term agency metering plan in capital project budgets.
- Job Order Contracting (JOC) – Job Order Contracting is suitable for relatively small, simple projects which do not require much design.
- Energy Savings Performance Contracting (ESPC) – Energy Savings Performance Contracting can only be used to deliver energy-saving projects. Advantages include the ability to select systems and equipment that are compatible with existing proprietary controls, potential to find funding by wrapping the metering project into a larger energy retrofit, and commissioning of the system by the Energy Services Company (ESCO).

Choose the project delivery method that best suits the scope of your project.

Appendix 1 - Long Term Planning and Greenhouse Gas Emissions Limits

At this Department of Ecology link, there is a Strategy for Reducing Greenhouse Gas Emissions template. Use this format to identify strategies to reduce emissions, and track measurable progress toward goals. This will clearly identify the challenges created when new construction adds to the energy used by agency or college facilities. Creating a strategy like this for your agency or college is the first step toward reaching your GHG reduction goals: *http://www.ecy.wa.gov/climatechange/WAleadership.htm*

Agencies and colleges in Washington State are required to meet Greenhouse Gas (GHG) emissions limits. Your agency or college has probably identified GHG reduction goals, and strategies to meet those goals. These goals and strategies should be considered in facilities capital and operating decisions. Fossil fuel use, in the form of electricity, natural gas or vehicle fuels, creates the vast majority of GHG emitted by state agencies and colleges in Washington State. Reducing energy use in buildings reduces GHG emissions. For instance, reducing campus building energy use by 10% is likely to result in about a 10% reduction in the GHG emissions associated with those buildings. It is possible to further reduce building GHG emissions by switching to green energy sources such as solar photovoltaic panels.

Your agency or college GHG reduction strategy will identify how much you must reduce agency or college building energy use in order to meet agency-wide or college-wide GHG reduction goals. The strategy will identify short term and long term goals. Your 20 Year Facilities Plan will be designed to reach your long term GHG reduction goals. You will advise management of the most cost effective ways to reduce energy use in your facilities. Use your building energy metering system to find opportunities to reduce emissions, and to determine whether you are reaching the GHG reduction goals for each campus, and for each building.

New building and renovation projects as currently delivered are adding to the energy use of agencies and colleges. Future energy use can be limited by choosing to fund new buildings and renovations that do not add to agency or college energy use. It is possible in some cases to design a new building to use very little energy, and incorporate renewable energy into the building so that it uses less energy than it makes. Properly designed and funded renovations can dramatically reduce the energy use associated with existing space. Funding requests should account for how a proposed building or renovation will impact energy use reduction goals. Alternatives that do not add space, such as shared spaces, hoteling, distance learning, cloud computing, or other creative solutions, should be seriously considered. Buildings have a very long life. They should be durable, flexible and designed for the low energy use future. Statewide GHG limits cannot be achieved if the baseline is increased to allow for new construction. New construction must not add to GHG emissions, and renovations must be designed to dramatically reduce energy use.

Appendix 2 - Operational Energy Saving Measures

Adequately staff facilities maintenance and operations

Facilities maintenance and operations must be adequately staffed to properly manage energy use, and keep equipment working efficiently. Routine maintenance such as filter replacement and proactive maintenance practices keep energy use lower and extend equipment life. Adequate staffing is required to keep occupancy schedules up to date to avoid using energy when buildings are not occupied. The facilities maintenance and operations staff need adequate time to observe, troubleshoot and adjust building systems to reduce energy use.

Get executive management level support for reducing energy use

Agency and college facilities staff and building occupants respond to clear direction from agency executive management. Facilities staff do not have control over operational decisions by management or other parts of the organization which affect energy use. Adequate funding for energy conservation measures and facilities staffing is often determined by agency or college management.

Provide Resource Conservation Managers (RCMs)

Resource Conservation Managers (RCMs) find energy savings in buildings and daily activities. Agencies that have an RCM often use that person to prepare sustainability reports and reports on greenhouse gas emissions or energy use.

Create a culture of conservation and sustainability

Thousands of decisions which affect energy use are made every day by building occupants and agency staff at every level. No cost or very low cost opportunities to save energy can be found in these day to day decisions. The best opportunities for reducing energy use dramatically involve changes in how the agency or college executes its mission. These opportunities are not under control of the building maintenance and operations staff. By creating a culture of conservation and sustainability throughout the agency, everyone is enabled to find the best way to complete their mission while reaching for energy reduction goals. This is in line with principles of LEAN, a process to create more value for customers with fewer resources.

Links to operational energy savings resources:

BetterBricks

An initiative of the Northwest Energy Efficiency Alliance, BetterBricks champions the guiding principle that commercial buildings should be designed and operated with energy top of mind. The goal is to accelerate the adoption of energy efficiency best practices among real-world building professionals. NEEA's BetterBricks initiative provides education & training workshops, seminars and conferences to equip Northwest building professionals with technical and business skills to help them better incorporate energy efficiency into their business practices: http://www.betterbricks.com//operations

Department of Energy, Energy Efficiency and Renewable Energy (EERE)

An operational best practices guide from the US Department of Energy highlights strategies that save energy without significant capital investment: O&M Best Practices: A Guide to Achieving Operational Efficiency, Release 2.0, Energy Efficiency and Renewable Energy (EERE), A Product of the FEMP O&M Center of Excellence. G. P. Sullivan, R. Pugh, A. P. Melendez, and W. D. Hunt (Pacific Northwest National Laboratory). July 2004. http://eere.pnnl.gov/building-technologies/pdf/o_m_guide_2004.pdf

Department of Enterprise Services (DES) Energy Program

The DES Energy Program provides comprehensive project management and other services to help our clients reduce energy and operational costs, and reach sustainability goals. The DES Energy Saving Performance Contracting program provides building energy retrofits for state agencies, colleges, universities, municipalities and K-12 schools: http://www.des.wa.gov/services/facilities/energy/pages/default.aspx

EPA's Energy Star

There are many helpful resources at the Environmental Protection Agency's Energy Star website, including how to make a business case for energy efficiency, how to inspire building occupants to participate in energy efficiency efforts, and examples of what other facilities managers are doing to get operational energy savings: http://www.energystar.gov/buildings/about-us/how-can-we-help-you/build-energy-program?s=mega

The EPA's Energy Star Guidelines for Energy Management is a guide to building a strategic energy management program. "Among the themes that have emerged over the years: Energy programs save more than energy projects. You won't get far without a commitment from the top. In addition to starting a program, you also need a plan to sustain energy efficiency. And success depends on whether you can successfully create a culture of energy efficiency within your organization." http://www.energystar.gov/buildings/about-us/how-can-we-help-you/build-energy-program/guidelines

The Smart Buildings Center

The Smart Buildings Center (SBC) is a non-profit organization that supports growth and innovation in the Northwest's energy efficiency industry. The SBC serves as a hub for industry activities, raises the visibility of energy efficiency companies and projects, and creates resources to help industry tackle a range of important issues. One of the SBC's primary goals is to increase building owner and investor confidence in building energy projects by catalyzing the industry shift from predicted to measured energy savings. They may be able to assist with data analytics at no or low cost: http://www.smartbuildingscenter.org

Washington State University (WSU) Energy

WSU Energy organizes the WSU Energy Conference each year at Leavenworth, Washington. WSU Energy staff includes energy engineers, energy specialists, technical experts, software developers, energy research librarians and more. The WSU Energy Mission is to advance environmental and economic well-being by providing unmatched energy services, products, education and information based on world-class research: http://www.energy.wsu.edu/Documents/CreatingEnergySolutions-China_FINAL.pdf

Appendix 3 – Energy Information Systems

Metering Best Practices: A Guide to Achieving Utility Resource Efficiency, Release 2.0. G. P. Sullivan, W. D. Hunt, R. Pugh, W. F. Sandusky, T. M. Koehler and B. K. Boyd. August 2011. See Chapter 3, "Metering Planning" and Chapter 7, "Data Analysis and Use." http://www1.eere.energy.gov/femp/pdfs/mbpg.pdf

Lawrence Berkeley National Laboratory's Building Energy Information Systems and Performance Monitoring Tools website is a great resource on this topic. Building Energy Information Systems (EIS) are broadly defined as the software, data acquisition hardware, and communication systems used to store, analyze, and display building energy data. EIS often include analysis methods such as baselining, benchmarking, utility and carbon tracking, load profiling, and energy anomaly detection: http://eis.lbl.gov/

Appendix 4 – Making a Business Case for Metering Systems

- *Metering Best Practices: A Guide to Achieving Utility Resource Efficiency, Release 2.0. G. P. Sullivan, W. D. Hunt, R. Pugh, W. F. Sandusky, T. M. Koehler and B. K. Boyd. August 2011. See Chapter 3, Metering Planning. http://www1.eere.energy.gov/femp/pdfs/mbpg.pdf*
- *Guidance for Electric Metering in Federal Buildings. US Department of Energy, Energy Efficiency and Renewable Energy (EERE). February 3, 2006. See pages 9 – 15, Metering Cost-Effectiveness. https://www1.eere.energy.gov/femp/pdfs/adv_metering.pdf*
- *Submetering Business Case: How to calculate cost-effective solutions in the building context, A Knowledge Network production by GSA's Office of Federal High Performance Green Buildings. http://www.gsa.gov/portal/mediaId/156791/fileName/Energy_Submetering_Finance_Paper_Knetwork_2012_11_269(508).action*

Computing Cost Effectiveness of Metering Systems

Although there are other benefits to metering, it is often the dollar savings associated with the energy reductions that are used to justify a metering project to a chief financial officer or board. This is often expressed in terms of simple payback (in years):

$$Simple\ Payback = Initial\ Cost/(Annual\ Savings - Annual\ Maintenance)$$

where

$$Annual\ Savings = Annual\ Utility\ Bill * \%\ Annual\ Savings$$

The simple payback methodology can be used to calculate the annual utility bill savings or the minimum annual utility bill that is required to justify the installation cost:

$$Desired\ Simple\ Payback * (Annual\ Savings - Annual\ Maintenance) = Maximum\ Initial\ Cost$$

or

$$\frac{\left(\frac{Installed\ Cost}{Desired\ Simple\ Payback}\right) + Annual\ Maintenance}{\%\ Annual\ Savings} = Minimum\ Annual\ Utility\ Bill$$

For reference the U.S. Department of Energy Guidance for Electric Metering in Federal Buildings[i] defines a meter as cost effective if it achieves a 10 year simple payback while assuming at least 2% annual energy savings. Higher savings should be considered based on the intended use of the meter data. This guide also references a $25 per month average maintenance cost per meter.

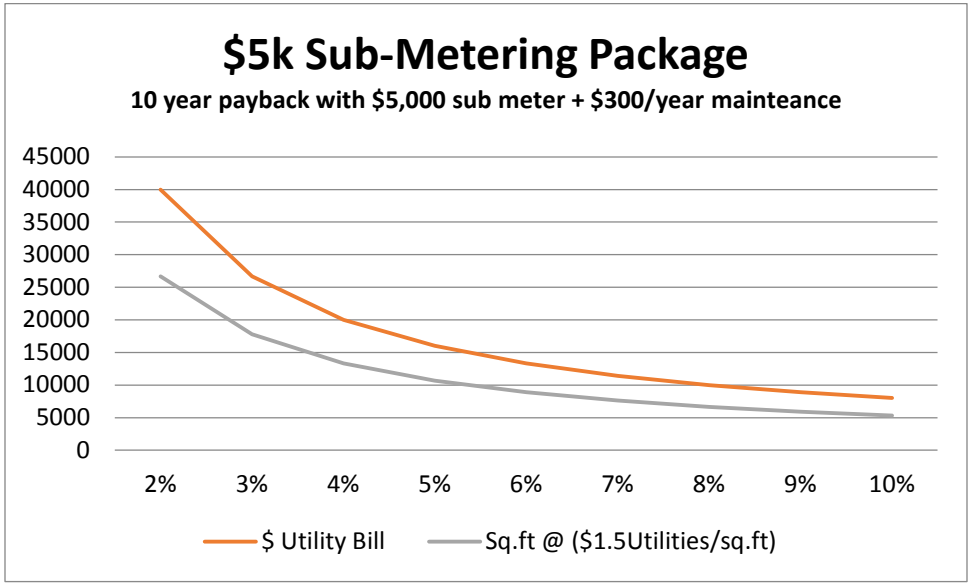
Targeting a 10 year simple payback and using $25 per month as a working maintenance cost per meter are reasonable starting points. Also consider how you intend to use the meter data and how much energy savings you expect to achieve. A 5% annual savings on your utility bill is a reasonable minimum achievement to expect if you plan to review and act on the meter data you collect. It is important to remember that installing meters doesn't save energy, using meter data to inform decisions and take actions save energy. The more time you spend analyzing and acting on your data the more energy, and dollar, savings you can achieve.

Unfortunately, because your buildings are not currently metered you won't know the actual utility bill for the building. One way to estimate this value is to divide the campus utility bill by the total campus square footage and multiply by the building square footage.

The easiest approach may be to use the simple payback formula and the total campus utility bill to calculate how much money you can spend on meters campus wide. This strategy can be used to develop a campus-wide metering budget which can then be strategically allocated towards

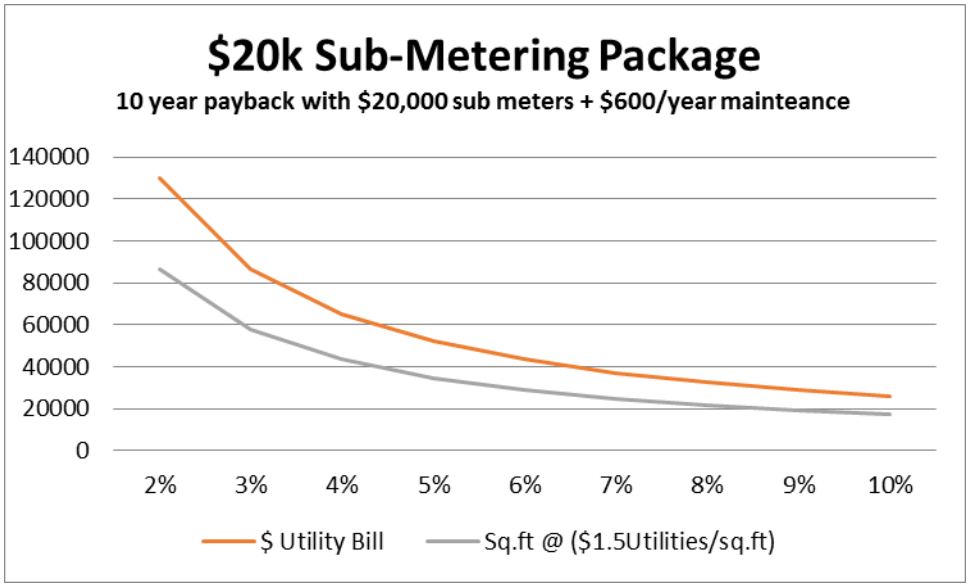
complete energy metering of the buildings you think are using the most energy. You may also want to consider submetering energy using equipment in large buildings, or focus on installing low cost electrical meters throughout the campus.

To provide some rough guidance the following analysis has been completed based on a generic utility cost of $1.5 per sq.ft.



The chart above shows the utility bill and the building size that would be cost effective to meter assuming a metering package can be installed at a cost of $5,000 + $300/year maintenance while targeting a 10 year simple payback. If you expect to achieve only 5% energy savings per year as a result of the installation the meter would be cost effective with a utility bill greater than $16,000 which generally can be associated with buildings greater than 10,000 sq.ft. in size. In most cases it will make sense to install an electric meter on all buildings that are 10,000 sq.ft. or larger.

The chart below examines a more expensive metering package that costs $20,000 + $600/year in maintenance. If we target the same 10 year simple payback and 5% annual energy savings this more expensive installation would be cost effective if the utility bill exceeds $52,000 which generally can be associated with buildings larger than 35,000 sq. ft.



A simple payback calculation is generally seen as an acceptable method to evaluate the cost effectiveness of a meter installation. However a more complex Life Cycle Cost Analysis will evaluate the benefits of the meter beyond the point of payback and would take into consideration the cost of money to an institution. For example, if we use the Washington State Life Cycle Cost Tool[ii] to evaluate the same metering package costing $20,000 + $600 in maintenance for a building with a $52,000 utility bill. A 5% annual savings does more than create a break-even, it actually creates $7,500 of present valued dollars for the institution over 15 years.

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[i] U.S. Department of Energy, Guidance for Electric Metering in Federal Buildings – February, 2006 https://www1.eere.energy.gov/femp/pdfs/adv_metering.pdf
[ii] Office of Financial Management, *Washington State Life Cycle Cost Tool* – Accessed 8/6/14 http://www.ofm.wa.gov/budget/capitalforms/lifecyclecosttool.xlsb