Making the Case for Energy Metering and Monitoring at Industrial Facilities

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ABSTRACT

The old business axiom 'You cannot manage what you do not measure' is certainly true for industrial facilities and industrial energy management. Yet many industrial organizations have limited metering and monitoring beyond the utility-installed meters necessary for billing. This paper examines the barriers to submetering and monitoring in industrial facilities, and discusses practical ways to overcome them. The discussion is based on interviews with a cross section of both industrial energy managers and metering and monitoring equipment vendors. The paper also includes examples of companies benefiting from submetering and monitoring, including 3M Corporation and PPG Industries.

The role of submetering and monitoring in emerging emissions reporting programs and voluntary energy programs such as the Department of Energy's Superior Energy Performance is discussed as well.

Introduction

Historically, energy costs at industrial facilities were considered to be fixed and uncontrollable. This line of thinking is less prevalent now. Rising energy costs, as well as the recent interest in corporate social responsibility, environmental sustainability, and greenhouse gas (GHG) emissions reduction by industrial organizations have resulted in increased attention to industrial energy use. More companies are pursuing energy efficiency projects, adopting energy management strategies, and benchmarking their energy consumption. In addition, industrial organizations such as 3M Corporation and PPG Industries are making aggressive voluntary GHG and energy reduction pledges, either based on their own internal goals, or with initiatives such as the Carbon Disclosure Project, the Environmental Protection Agency's ENERGY STAR program, and the Department of Energy's *Save Energy Now* LEADER and Superior Energy Performance programs.

The result of this redoubled attention to energy use is an increase in the measurement and monitoring of energy beyond what is available through utility billing based on a main meter. Submetering is the installation and monitoring of additional permanent meters to monitor the energy use by building, department, production lines, or equipment. Other examples include plant cost centers, data centers, chiller plants, boilers, or lighting systems.

What Data Is Measured?

Electricity is the most commonly measured form of energy, but many facilities also measure natural gas consumption and other forms of energy. More comprehensive metering and monitoring programs measure energy in terms of "WAGES" – water, air (compressed air), gas, electricity, and steam. In addition, facilities can use submetering and monitoring to measure chilled water, high temperature water, and temperatures in critical processes.

3M recently conducted a survey of Energy Champions at its major U.S. facilities to gain a better understanding of current submetering practices, the barriers overcome, and the benefits they have seen from submetering and monitoring (Schultz 2011). The survey results show that most 3M facilities submeter electricity to some degree of detail, and just over 50% monitor natural gas use. A smaller number of 3M facilities are submetering other energy/fuel sources, including steam, compressed air, fuel oil, chilled water, potable water, industrial water, nitrogen, and diesel. Table 1 lists the top six energy streams monitored by 3M, based this survey.

Table 1. Energy Sources and Fuels Submetered at 3M

Energy/Fuel Source	Number of Facilities (out of 100) Submetering
Electricity	74
Natural gas	51
Steam	13
Compressed air	12
Fuel oil	12
Chilled water	6

Source: Schultz 2011

Collected Data

The data that companies collect and the frequency of measurement depend on their goals for a submetering program. There are four predominant levels of metering that pertain to the frequency at which measurements are taken:

- One-time (spot) measurement;
- Run-time measurement;
- Short-term monitoring; and
- Long-term monitoring.

Spot measurements are used to understand instantaneous energy use, equipment performance, or loading. Equipment is not required to be installed permanently. Spot measurements are useful in trending equipment performance over time and measuring finite changes in system performance as a result of energy-efficiency projects.

Run-time measurements are made in situations where hours-of-operation are the critical variable. Magnitude of energy use is not measured, only duration. These measurements are useful for analyzing projects where the impact of use has been affected (i.e., hours of operating).

Short-term monitoring combines elements of run-time and one-time spot measurements into a time-series record of energy or resource use: magnitude and duration. Measurements are usually taken over a period of weeks or months, and usually do not span more than a year.

Long-term monitoring is the level of monitoring of most value to organizations seeking to fully understand and manage their energy performance. Both magnitude and duration of energy use are usually measured for an ongoing basis. The installation of monitoring equipment is usually permanent. Long-term monitoring allows for better understanding of variances in weather, occupant behavior, or other operating conditions.

Four levels of electricity submetering can be defined:

- Whole-plant metering;
- Panel/sub-panel metering;
- Circuit-level metering; and
- End-use-level metering.

As the level of metering becomes more specific, the diagnostic capability and level of effort required increases. Electrical panel/sub-panel metering focuses on loads connected at a panel (or sub-panel) as aggregations of specific loads. Examples of panel-level monitoring include lighting panels or motor panels where hours of operation or efficiency project validation are of interest. Circuit-level monitoring targets specific circuits of interest within panels or sub-panels. Examples of circuits that may be monitored include computers and lighting. The most specific level of monitoring is the end-use level, which allows isolation of a particular system or piece of equipment. Examples of end-use equipment that may be monitored include chillers, boilers, cooling towers, pumps and motors.

Other submetering levels can be defined that apply to all energy streams; not just electricity. For example, a large multi-plant industrial site could identify the following levels of submetering:

- Site-wide metering;
- Plant-wide metering;
- Department-wide metering; and
- Production line or process-level metering.

Significant energy-consuming systems such as compressed air, chilled water systems, and steam systems can be monitored individually in addition to the levels identified above. For instance, PPG's Lake Charles Chemical Complex in Louisiana has submetering at the cost center level, and also another level of submetering for large power consumers such as their chlorine circuits.

Metering Equipment and Technologies

A variety of equipment and technologies exist in the marketplace, representing a range of applications, accuracy, reliability, and costs. Solid state/digital electricity meters have gained prominence over the older mechanical and electro-mechanical by offering greater accuracy and an array of features such as data storage, diagnostic capabilities, two-way communication, alarms, and statistical capabilities. In addition, sophisticated new technologies allow ubiquitous electric devices such as overload relays and circuit monitors to function as submetering devices. These devices collect valuable energy consumption information, but that information is of no value unless it can be communicated, either to a local PC, an energy management or building automation software system, or a web-based service that can provide analysis of the data. A number of methods exist to collect, store and analyze the data. Often, existing electrical wiring can be used. Ethernet and, more recently, wireless communication are becoming common means of data transmission.

Monitoring of natural gas, steam, water, and other flow-related energy sources typically is done using in-line equipment. A variety of metering technologies exist, and the choice of technology for a given application is based on the fluid type, equipment and installation cost, and required accuracy. Steam flow can be challenging to accurately measure, and typically requires measurement of temperature and pressure (Almaguer 2006). In addition to flow meters with temperature and pressure compensation, vortex, ultrasonic, and venturi meters can be used to measure steam use. Vortex and coriolis (mass flow) meters are common for measuring natural gas.

A company looking for basic introduction to submetering and monitoring can start, for example, with simple digital kilowatt-hour meters for tracking electrical energy consumption, with the option of sending data (via pulse output) to a PC or energy management system.

Barriers to Submetering and Monitoring

Knowing the energy use of individual product lines, departments, or major energy-consuming equipment is of value to any plant manager or energy manager. However, the extent of submetering and monitoring in the industrial sector is small. Why is this? There are several reasons.

The initial barrier for a company looking to begin a submetering and monitoring effort is to overcome internal resistance to change. Facilities staff may be reluctant to change the status quo. Production line supervisors may not want their utilities disrupted due to downtime or perceived risks. Others may feel that the plant is already efficient, so understanding energy use at a finer detail is not necessary.

Next, getting approval and funds can be a substantial hurdle. While a number of companies attribute energy savings and reliability improvements to their metering and monitoring efforts, it is often difficult to calculate a projected return on investment (ROI). Without a reliable ROI, making the case for investing in metering and monitoring equipment can be a challenge, especially for organizations or facilities with no prior experience in metering and monitoring. (Schultz 2011)

Additionally, there are the logistical issues associated with installing the submetering equipment (Troyer 2011). Determining the locations, type and exact model of equipment requires an inspection of sensitive areas such as switch gear and motor control centers. This may require scheduling a shutdown unless weekend or planned shutdown time is available. The actual installation may require another shutdown. For electrical submetering, a plant may also have problems getting its local utility to schedule a time to temporarily shut off power. Gas utilities may be sensitive to the addition of metering equipment near their own meters. Once facilities address these equipment installation issues, they may still need to install the appropriate cabling and means of communications established. Organizations not experienced in submetering and monitoring should factor in a learning curve for personnel involved in the collection and analysis of the energy data.

Metering and monitoring equipment will require periodic maintenance and repair, as well as calibration. Therefore, a metering and monitoring program or protocol is necessary. The survey at 3M of 100 facility Energy Champions identified the following top barriers:

- Getting management approval;
- Unable to justify the equipment and installation costs;
- Lack of budget/funding for purchase and installation;
- Unable to calculate an ROI or payback; and
- Limited resources to install, operate, and maintain the equipment.

The survey asked respondents to identify the barriers that exist or were overcome in getting support and funding for metering and monitoring at their facilities.

Overcoming the Barriers

How can facilities staff or energy managers get past the barriers? Education is a good starting point. For example, John Troyer, a Facilities Manager with Schneider Electric, has developed technical documents that are used corporate-wide to provide plant-level engineering staff with a background on understanding and selecting metering equipment.

It is also important to educate plant and corporate management. A web search can provide a number of success stories that can be shared with management. Once management has an understanding of the potential benefits of submetering and monitoring, the next step is to gain their support for the purchase and installation of the equipment and any software.

Starting with basic submetering and monitoring equipment installed in just one area or monitoring one particular system will help to insure success. Such an approach will minimize initial costs and plant resources, and can be used to demonstrate that the overall benefits exceed the costs.

Incorporating a submetering and monitoring plan into a company's energy management plan will help guarantee support when seeking approval to purchase and install the equipment. If an organization does not have an energy management plan, then creating a submetering and monitoring plan can be the impetus for a broader energy management plan.

Company Motivations to Submeter and Monitor

What has motivated companies to overcome the barriers and proceed with submetering and monitoring? Typically, the motivation comes from a strong advocate at the corporate or facility level, such as a corporate energy manager or a site energy leader. This advocate, or energy champion, has the knowledge to discuss technical issues with line or process managers and address their concerns. This individual also is able to explain the potential benefits to senior management to obtain their commitment and possibly funding as well.

For a number of organizations, increasing awareness of the opportunities for energy efficiency improvements in the industrial sector has led to an interest in understanding where the opportunities lie within a facility. This awareness led these organizations to begin measuring energy use through metering and monitoring activities.

Just as some office building owners and apartment building owners now submeter and charge individual tenants for their energy use, some organizations, including 3M and PPG, have facilities managers who now allocate energy costs to individual departments or production lines based on energy use data provided by submeters. This "re-charge" of energy costs provides an incentive for these departments and groups to better understand how energy is used in their areas and seek opportunities to reduce energy use. The Electric Power Research Institute (EPRI) has found that allocating energy costs by submetering creates accountability within departments or processes and leads to 5-10% energy savings (Howe 2011).

Increasingly, company involvement in voluntary energy and greenhouse gas initiatives such as the U.S. Department of Energy's *Save Energy Now* LEADER program and the Carbon Disclosure Project is focusing attention on energy management planning and greenhouse gas reduction strategies. PPG, 3M, and over 100 other companies have committed to adopting continual energy improvement practices and reducing energy intensity by 25% over a 10-year period through the voluntary *Save Energy Now* LEADER initiative. Similarly, participation in voluntary carbon/GHG initiatives provides an incentive to reduce emission through energy efficiency, and indirectly to monitory energy consumption.

PPG, for example, joined the Carbon Disclosure Project a number of years ago and met its 2002-2012 goal of 18% GHG emission intensity reduction by 2006. PPG's commitment to environmental stewardship is helping to drive continuous improvement in productivity. Energy reduction provides cost reduction, one form of productivity improvement. At PPG, productivity and energy goals are an integral part of their strategic business plans. Such planning within industrial organizations can lead to a commitment to continual improvement in energy efficiency or energy intensity, thus creating the need to better understand energy use through metering and monitoring.

Benefits of Metering and Monitoring

Energy managers cite a number of benefits attributable to energy metering and monitoring. Most fundamentally, they stem from the "you cannot manage what you do not measure" adage. Having a better understanding of the energy use of individual departments, processes, and equipment in a facility allows facilities staff to identify areas for efficiency improvements (Troyer 2011). The finer detail of energy use allows identification of inefficiencies within a facility. Additionally, submetering allows the monitoring of *when* energy is used, not just the amount.

This measured energy information can help department or production line personnel become more aware of their energy use. A Boeing facility in Auburn, WA reduced energy consumption by over 22 percent over a two-year period several years ago as a result of improved production staff awareness. Savings resulted from no-cost actions such as turning off lights, air handlers, process equipment and auxiliary systems when not in use, adjusting temperature and pressure settings, as well as low-cost actions such as replacing steam traps and plugging compressed air leaks. (Santee Cooper Power 2002) Similarly, Nissan North America has used equipment monitoring to identify equipment that was unnecessarily running continually and other equipment that was cycling on and off more frequently than required (Roden 2011). Having energy data at the department or production line level also creates the potential for departmental accountability for energy costs.

Metering and monitoring provides measurement and verification (M&V) capability, allowing facilities staff to verify the energy savings of an implemented project, and ideally provide justification for engineering and implementing similar energy projects. This M&V capability then allows a company to benchmark departments, processes, equipment, or even plants against similar entities. This process is becoming common in the commercial buildings sector, but will likely become more popular and more valuable as industrial companies adopt metering and monitoring practices.

Monitoring can also identify demand spikes, as was the case for Schneider Electric's Peru, Indiana plant. Electricity monitoring led to the identification of a monthly test of a back-up air compressor as contributing to peak load at the plant. Armed with this information, the Facility Manager was able to reschedule this testing to an off-shift time, saving about $2,500/year in electricity costs (Studebaker 2010).

Further, energy monitoring can be used to improve equipment reliability and prevent downtime. Newer electrical metering devices can monitor power quality, power factor, harmonics, and thermal loads, providing additional functionality and increasing the value of metering and monitoring.

Based on frequency of response, the benefits seen by 3M's Energy Champions are closely aligned with the benefits identified by other organizations:

- Identifies areas for improvement, including
  - Leak identification;
  - Efficiency improvement;
  - Equipment quality issues;
- Better accounting of energy use and costs;
- Increased awareness and employee involvement; and
- Tracking of energy efficiency project savings.

Do Submeters Save Energy?

Metering and monitoring devices do not reduce energy consumption or demand. They simply record and transmit data for analysis. In addition, each piece of metering equipment imposes not just a purchase cost, but also an installation and a maintenance cost. Is metering and monitoring worth the investment? John Troyer of Schneider Electric reports having never failed to find an energy savings opportunity after installing a submeter (Troyer 2011). Metering and monitoring provides facilities personnel with the data for analysis, which can provide the knowledge to pursue energy efficiency as well as the other benefits described earlier.

Making the Business Case for Metering and Monitoring

The previously-mentioned benefits of submetering and monitoring provide a tremendous opportunity to improve the efficiency and the bottom line throughout a broad cross section of industrial organizations. While a number of organizations use submetering and monitoring to better manage their energy, the vast majority of organizations do not.

A common thread among the organizations with metering and monitoring programs is the presence of energy management policies, strategies, and plans that emphasize the pursuit of energy efficiency through continual improvement. Companies such as 3M and PPG have been addressing their energy footprint for a number of years. PPG's corporate energy management strategy specifically identifies measurement and verification as crucial to the continuous improvement of PPG's energy performance (Yigdall 2009). These energy management plans and policies should prioritize plants and/or areas to target for submetering and monitoring. At PPG, for example, low energy-consuming facilities are low priority for monitoring, while many energy intensive facilities are monitored with sophisticated systems.

Creating a corporate-wide energy management policy and implementing an energy management plan that includes a top management-driven commitment to continuous energy improvement are the most important actions an industrial organization can take to improve energy performance. That commitment to continuous improvement requires measurement and validation, thus creating the need for a metering and monitoring system that provides a level of detail on the energy use of the key aspects of the facilities within the corporation.

Facilities personnel often find it difficult to justify investing in a metering and monitoring program based on the typical financial business case. It is often thought that there is no direct return on investment or life cycle analysis. At PPG, as maintenance of old electrical substations and motor control centers is required, electrical switch equipment upgrades and smart metering capabilities are being incorporated. This has enabled improved measurement of electrical energy utilization along with power factor measurement. Correction of power factor deficiencies has led to direct savings beyond improvements in process and facilities effeciencies.

Policy Perspectives

Given the limited, though increasing, attention paid to energy efficiency by large segments of the industrial sector, the widespread adoption of metering and monitoring practices in the U.S. is not likely to occur without a push from outside the sector. An important step would be for utility companies to provide incentives, such as rebates, to encourage the installation of metering and monitoring devices. Incentives at the state level may also be of value, but utility companies, both electric and gas, already have established relationships with most industrial facilities and therefore can have a broader and more immediate impact.

The Environmental Protection Agency's Mandatory Reporting of Greenhouse Gases Rule will require large emitters to report emissions data. This reporting requirement will likely have limited impact on metering and monitoring of energy use in the industrial sector since the rule does not require reductions in emissions; just reporting. However, voluntary greenhouse gas reporting, reduction and trading programs such as the Carbon Disclosure Project, carbonfund.org, and the Chicago Climate Exchange do encourage emissions reductions, and hence indirectly promote energy submetering and monitoring. With energy savings being vital to emissions reductions, organizations participating in these programs are more likely to set energy use baselines and monitor their energy consumption.

Another way to foster the adoption of metering and monitoring practices is for existing federal programs to place a greater emphasis on the benefits of metering and monitoring. For example, the Environmental Protection Agency's ENERGY STAR for Industry program provides an array of resources to help companies initiate energy management programs. However, metering and monitoring receives limited mention, being just one of 28 factors in their Facility Energy Management Assessment Matrix meant to help companies self-evaluate their energy programs. Within the Department of Energy (DOE), the Industrial Technologies Program has a wide variety of respected technical resources, but little in the way of guidance on submetering or monitoring. The creation of best practices guides, case studies, submetering and monitoring plan templates, and other documents specific to the industrial sector would be beneficial to industrial organizations.

An emerging DOE program, Superior Energy Performance, has the potential to impact the penetration of metering and monitoring in the U.S. Superior Energy Performance will be a voluntary certification program that requires companies to develop and implement energy management programs. The program will include a measurement and verification (M&V) component, which can be either self-verification or 3rd party. This M&V component will encourage greater metering and monitoring. Further, Superior Energy Performance will require companies to adopt ISO 50001, a voluntary international energy management standard set to be published in the fall of 2011. The standard will provide guidance on energy measurement and benchmarking. Its publication and use should have a positive impact on the adoption of metering and monitoring practices in the industrial sector.

News reports of stockholders and board members pushing organizations to become more sustainable, measure and reduce greenhouse gas emissions, and use energy more efficiently are becoming common. These actions should increase the prevalence of submetering and monitoring over time. Companies with metering and monitoring plans in place will be prepared to react to directives that come from boards or stockholders. Trade associations and business groups such as the Business Roundtable, which already have policy statements and other documents espousing the importance of environmental stewardship and energy efficiency, can provide a service to their member companies by providing resources that explain and promote the benefits of submetering and monitoring.

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