Maximizing Energy Savings with Energy Management Systems

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ABSTRACT

This is the third in a series of three articles on enterprise energy management (EEM) systems featured in *Strategic Planning for Energy and the Environment*. The first article described the current state-of-the-art in EEM systems and their associated benefits in controlling energy cost, quality, and reliability (see Vol. 22, #4). The second piece considered energy in terms of managing the associated cost and reliability risks to businesses (Vol. XX, #X).

As the field of energy management matures, so do the tools and best practices available to ensure that the energy required by an organization is used in the most efficient way possible. In the past, energy management practices consisted primarily of replacing inefficient equipment and then using any number of methods to estimate the savings gained. Studies performed by the Department of Energy (DOE) and the Texas State Energy Conservation Office (SECO) have shown, however, that energy savings can be dramatically increased and maintained over time by adopting and implementing consistent energy management practices and recognized measurement and verification procedures.

As energy management standards and best practices begin to see widespread adoption, the information systems required to support them will play a crucial role in their implementation and success. The enterprise energy management systems described in the previous articles will not only address shorter term cost, quality, and reliability concerns, but can also provide the detailed data and analysis capabilities required to ensure that energy management strategies and conservation measures

are on track throughout an organization. Organizations can apply EEM systems to gain a comprehensive understanding of current energy performance, plan and select cost-effective energy conservation measures, track performance of measures that have been implemented, and verify the savings realized.

Over the last several decades, there has been increasing interest and activity in the field of energy management. A Lawrence Berkeley National Labs (LBNL) study of energy efficiency projects completed by US energy service companies over a ten-year period shows that total project spending has increased from roughly $500 million in 1990 to more than $2 billion in 2000 [1].

Energy management practice has traditionally focused exclusively on technologies that increase the energy efficiency of key energy-consuming processes and equipment. Rebuild America, a US Department of Energy (DOE) energy efficiency program, lists lighting and HVAC equipment upgrades among the most commonly implemented energy efficiency measures [2]. The US DOE Energy Information Administration (EIA) lists a variety of energy management activities for several industrial sectors, including waste-heat recovery and deployment of variable-speed drives [3].

Although there is little doubt that upgrading equipment and processes is a key ingredient to increased energy efficiency, there have always been concerns that traditional deployment practices have not resulted in consistent (and long-term) energy savings. While the LBNL study mentioned above notes a steady increase in energy efficiency project spending over time, it also acknowledges that there is a wide variation in typical energy savings [1].

There has been considerable effort over the last several years to define standards and best practices that increase the performance of energy efficiency projects and make the savings realized more predictable and repeatable. The International Performance Measurement and Verification Protocol (IPMVP), for example, provides best-practice methods for measuring and verifying the results of energy efficiency projects in commercial and industrial facilities [4]. MSE 2000, an energy management standard developed by the Georgia Institute of Technology and accredited by ANSI, specifies a management infrastructure for increasing energy efficiency and reducing costs [5]. Both of these standards move beyond traditional energy efficiency practices and into the realm of more comprehensive *strategic energy management* practices that resemble the structure and discipline found in best-practice management systems like ISO 9000 and 14000.

Strategic Energy Management

As the field of energy management matures, the knowledge gained from thousands of energy efficiency projects is driving a transition from traditional tactical practices (one-time "build-and-forget" projects) to more comprehensive best practices (involving active management throughout the lifetime of the project). This strategic approach to energy management is endorsed by a number of international organizations, including Energy Star (US), Natural Resources Canada (Canada), and Action Energy (UK). Although there are subtle differences between the energy management strategies proposed by these organizations, Table 1 highlights the main elements found in all of them.

Like many modern management practices, the strategic energy management approaches described by these organizations highlight the need for an information system to set goals, track performance and communicate results. The MSE 2000 energy management standard calls out the need for an information system in several areas, and provides several sample reports in its appendix [5]. Several documents from Action Energy, including *Introducing Information Systems for Energy Management* [6] and *Monitoring and Targeting in Large Companies* [7] provide rich detail about the role that information systems play in strategic energy management.

A strategic energy management approach that includes an energy information system has the power to increase energy savings above and beyond the savings realized by traditional tactical practices alone. One US DOE paper studied energy efficiency projects at more than 900 buildings and found that projects that implemented best practices in measurement and verification realized higher savings (both initially and over time) than comparable projects, yielding an additional return on investment of nearly 10 percent [8]. When combined with strategic energy management practices, a modern enterprise energy management (EEM) information system can provide the tools an organization needs to evaluate potential energy efficiency projects and verify results.

Enterprise Energy Management Systems

An enterprise energy management (EEM) information system supports the strategic energy management process described above by:

Table 1. Elements of Strategic Energy Management

Corporate Commitment	An effective strategic management plan requires a strong commitment to continuous improvement throughout the organization.
Evaluate Current Performance	Conduct an inventory and energy audit, and then create a profile and baseline of energy use at all key points.
Set Performance Goals	Energy performance goals provide direction for decision-making and serve as a foundation for tracking and measuring success.
Action Plan	The action plan drives and guides everyone in the organization to focus and prioritize their energy efficiency efforts.
Educate and Motivate Participants	The ultimate success of a plan will depend on the motivation and capability of the managers and employees implementing its components
Evaluate Ongoing Performance	Sustaining improvements in energy performance and guaranteeing long-term success of a plan requires a strong commitment to continually evaluate performance.
Communications Strategy	A communications strategy provides the framework for promoting energy management efforts throughout an organization.
Recognition Strategy	Identifying and communicating the contributions of all participants provides a solid foundation on which to build a successful energy management strategy.

- Capturing data about current energy performance to form a baseline;

- Providing the information required to set and track energy performance goals; and

- Generating reports and key performance indicators (KPIs) that communicate ongoing energy performance to managers and energy project participants.

Figure 1 shows the typical components that form a modern EEM information system. Intelligent, microprocessor-based devices measure energy use at key points within one or more facilities and communicate these data back to head-end software via a communications network. The software archives these data, processes them as required, and presents them to the user in a variety of ways (e.g. using a web browser or by sending messages to wireless devices).

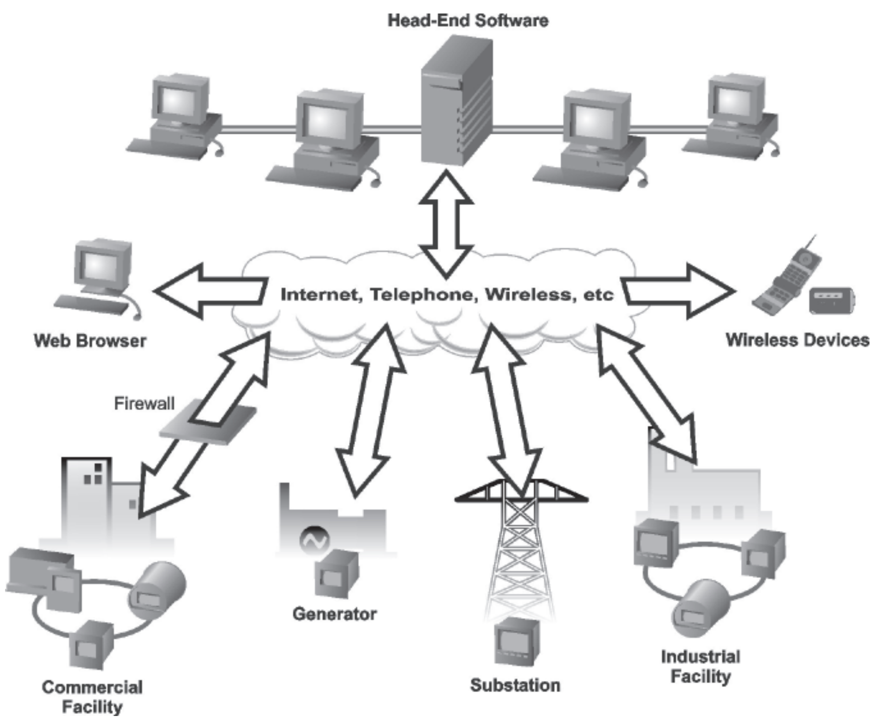

Figure 1. Enterprise Energy Management System

An EEM information system can be applied in several ways to support strategic energy management goals. The following sections describe four key types of EEM system applications: modeling and forecasting, benchmarking, energy use and cost analysis, and measurement and verification.

Modeling and Forecasting

Modeling building or process energy usage normally involves gathering energy consumption data and plotting this against some variable (such as degree-days or production activity) that represents the primary driver of that energy consumption. For buildings, the rate of heat loss (or gain) is directly related to the difference between inside and outside temperatures, so there is normally a direct relationship between the energy consumed by a building and degree-day measurements. For production processes where energy use is largely determined by the physics of the process (such as heat-based and chemical processes), there is normally a direct relationship between the energy consumed and production volume.

As an example, consider the scatter plot in Figure 2 showing energy consumption vs. production volume for some industrial process. Each point on the plot shows the production volume (in tons) and the corresponding energy consumption (in MWh) for a particular day. After a number of points have been added to the plot, it is apparent that there is a direct relationship between production volume and the amount of energy consumed. The "best fit" straight line added to this plot provides us with a model that describes how energy consumption varies with production volume. This model can be used to forecast energy consumption for a given production volume, and this property has a number of useful applications, ranging from predicting energy consumption for scheduled production runs to predicting the energy savings possible if proposed energy efficiency measures are taken.

Several excellent references from Action Energy that describe this modeling process in more detail include *Monitoring and Targeting in Large Companies* [7] and *Degree Days for Energy Management* [9].

Benchmarking

In energy management practice, benchmarking is a straightforward method for comparing the energy consumption of different entities (which might be buildings, equipment, or processes) against each

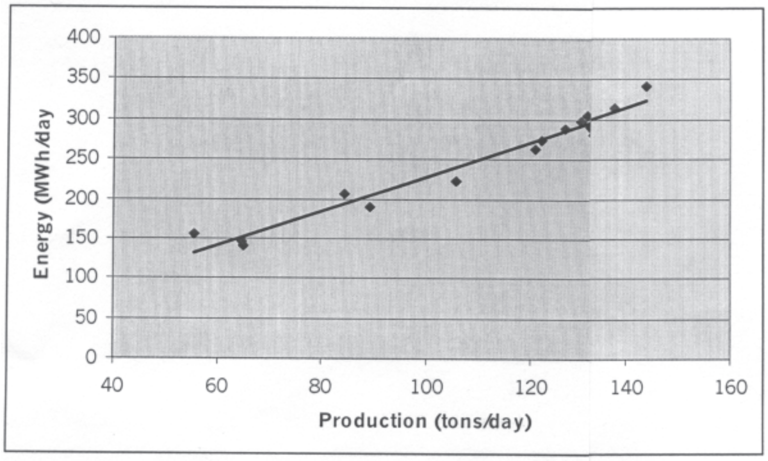

Figure 2. Energy Consumption vs. Production

other or against recognized reference standards. One key step in the benchmarking process is to normalize energy consumption into some key metric (such as kWh/sq.ft. or MWh/ton produced) to allow an "apples-to-apples" comparison between entities.

Consider the benchmarking chart shown in Figure 3, which shows electricity consumption (in kWh/sq.ft./year) for several buildings. The first five bars (from left to right) show electricity consumption for buildings A through E, the sixth bar shows the average consumption of these five buildings and the seventh bar shows the "best practice" consumption of similar buildings in the same region. An energy manager responsible for buildings A through E can immediately see that some buildings (like B and E) are more efficient than others (like C and D), and that this portfolio of buildings (on average) is less efficient than the "best prac-

Sample Data for Benchmarking

Bldg	Energy
Bldg A	32.5
Bldg B	28.7
Bldg C	42.4
Bldg D	37.7
Bldg E	30.3
Bldg Ave	343.32
Reference	30

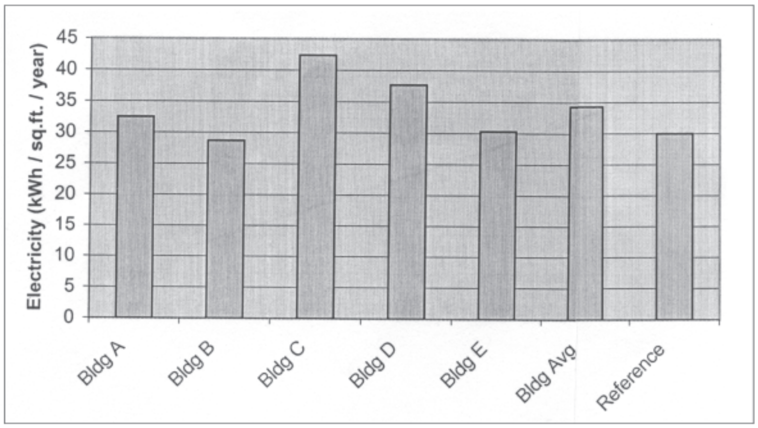

Figure 3. Electricity Consumption Benchmark

tice" reference benchmark. This straightforward comparison provides the energy manager with a starting point, likely leading to further investigation to determine why some of the buildings are more efficient than the others and ultimately resulting in action to increase the efficiency in the under-performing buildings.

The Rebuild America program created by the US Department of Energy offers a *Benchmark Your Building* guide that provides sample energy and cost benchmarks for a variety of building types in the United States [10].

Energy Use and Cost Analysis

A key part of controlling energy use and cost is understanding where and when energy is consumed within a facility. A breakdown of energy use and cost for equipment and processes that are key contributors is often the first step towards understanding current energy performance and targeting the energy conservation measures that will yield the greatest savings.

One study highlighted the contribution of various systems within a building towards total electrical energy consumption, both in terms of annual energy use and coincident peak demand. The electrical energy use was displayed using two pie charts to highlight the importance of considering both where and when energy is consumed—although cooling accounted for only 18 percent of annual energy consumption in the example, it represented 25 percent of the annual peak demand for the building. Since electrical demand charges can often represent nearly half of the electrical energy charges for a facility, energy conservation measures that target electrical demand reductions can yield the highest potential energy cost savings.

Measurement and Verification

The process of determining energy or demand savings by comparing measured energy use or demand before and after implementation of an energy conservation measure (ECM) is commonly known as *measurement and verification*. The internationally-recognized standard for measurement & verification practice is IPMVP 2001 [4], which provides an overview of current best practice techniques for verifying the results of energy efficiency projects in commercial and industrial facilities.

The IPMVP generally defines energy savings as follows:

$$\textit{Energy Savings} = \textit{BaseYear Energy Use} - \textit{Post-Retrofit Energy Use} \pm \textit{Adjustments}$$

where *adjustments* is the term in this equation used to bring energy use in the two time periods to the same set of conditions. Several conditions may affect energy use from one time period to the next, including weather, building occupancy, and production volume.

Table 2 provides a summary of the measurement and verification options specified by Volume I of IPMVP 2001.

An EEM information system can play a key role in gathering energy use data both before and after an ECM is implemented, as well as the analysis and reporting capabilities required to predict potential savings and show the actual savings achieved. The continuous measurement and analysis capabilities of an EEM system also provide information that can be used to improve building or process operations in real-time, increasing the benefit gained by energy conservation measures.

Conclusion

The knowledge gained from the deployment of energy efficiency projects throughout the last several decades is driving a transition from traditional tactical practices to more comprehensive *strategic energy management* practices. Like many modern management practices, a strategic energy management approach highlights the need for an information

Table 2: Summary of IPMVP 2001 M&V Options

Option A Partially Measured Retrofit Isolation	Savings are determined by partial field measurement of energy use by the system to which an energy conservation measure (ECM) was applied. Partial measurement refers to the fact that some (but not all) key parameters may be stipulated rather than measured, assuming the total impact of possible errors will not significantly affect the resulting savings. Measurements may be short-term or continuous.
Option B Retrofit Isolation	Savings are determined by comprehensive field measurement of energy use by the system to which an ECM was applied. Measurements may be short-term or continuous and are taken throughout the post-retrofit period.
Option C Whole Facility	Savings are determined by taking energy measurements at the whole facility level. Measurements may be short-term or continuous and are taken throughout the post-retrofit period.
Option D Calibrated Simulation	Savings are determined through simulation of the energy use of component systems or the whole facility. Energy use simulation is calibrated with utility billing data and/or end-use metering.

system to set goals, track performance, and communicate results. An EEM information system can support strategic energy management by capturing data about current energy performance, assisting in the creation and tracking of energy performance goals, and communicating results to managers and energy project participants.

Specific EEM system applications that support strategic energy management include modeling and forecasting, benchmarking, energy use and cost analysis, and measurement and verification. These applications can be combined to form powerful information tools that allow organizations to gain a comprehensive understanding of current energy performance, plan and select cost-effective energy conservation mea-

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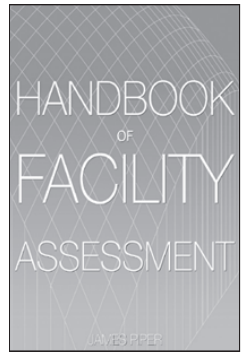

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