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U.S. DEPARTMENT OF ENERGY

A Primer on Organizational Use of Energy Management and Information Systems (EMIS)

Lawrence Berkeley National Laboratory

NOVEMBER 2015

U.S. DEPARTMENT OF ENERGY

Contents

Acknowledgements

This guidance was developed with the input of BBA public- and private-sector members with the aim of developing a holistic primer on the planning, implementation, and usage of EMIS technologies, including multi-year guidance for organizational integration and scale-up. It represents a synthesis of best-practice insights gained through several years of collaboration between Lawrence Berkeley National Laboratory and key members of industry, including EMIS vendors, users, and subject matter experts. We would like to thank and acknowledge review comments provided by:

- Aaron Daly, Whole Foods Market
- Anand Natarajan, City of Cleveland, Ohio
- Ben Sullivan, County of Kauai, Hawaii
- Michael Groppi, CBRE
- Patrick Ferguson, CBRE
- Patrick Hagan, Wawa
- Pat Lydon, Legacy Health System
- Michael Forrester, City of Cincinnati, Ohio
- Michael O'Connell, Retail Properties of America, Inc.
- Tom Riley, Hospital Corporation of America

Glossary of Terms

Standard terminology is important to have meaningful dialogue and common understanding. It is recommended that readers who are not familiar with energy management and analysis should review the glossary of useful terms before reading the main text of this primer.

Baseline: A representation of "standard" or typical energy performance, used for comparative purposes. Baseline may be expressed according to a variety of metrics and may account for weather or other independent variables that influence energy consumption.

Benchmarking: Comparing building energy performance to that of similar buildings (cross-sectional benchmarking) or its own historic performance (longitudinal benchmarking). Benchmarking may also be performed at the system or component level.

Building Automation System (BAS): A system that is designed to control building operations and indoor climate.

Communication Protocols: Standardized rules governing the transmission of information between devices. Common protocols for building data include, for example, BACnet, LonTalk, and Modbus.

Cumulative Energy Savings or Cumulative Sum of Energy Savings (CUSUM): Sum of the total accrued energy savings or increases over a certain time frame, relative to the baseline.

Degree Day: A measure of the heating or cooling load on a building relative to a "base" outside air temperature (e.g. 65°F). It is commonly calculated as the difference between the mean daily temperature and the "base" temperature.

Demand: The rate of energy use by a particular building or system, i.e., power. Common units of energy demand are kilowatts (kW) for electricity, tons for chilled and hot water, and therms per hour or cubic feet per minute for gas.

Demand Response: Changes in electric usage by customers in response to changes in the price of electricity over time or when system reliability is jeopardized.

Energy Information System (EIS): Software, data acquisition hardware, and communication systems used to store, analyze, and display building energy data.

Energy Management and Information System (EMIS): A broad family of tools and services to manage commercial building energy use. These technologies include, for example, energy information system, equipment-specific fault detection and diagnostic systems, benchmarking and utility tracking tools, automated system optimization tools, and building automation systems.

Energy Savings: A reduction in energy use often quantified by accounting for key normalization factors such as weather or hours of operation.

Energy Use Intensity (EUI): A unit of measurement that describes a building's energy use, relative to its size, on an annual basis. The common metric is KBtu/sf/yr.

Greenhouse Gas (GHG) Emissions: The carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) gases released into the atmosphere as a result of energy consumption at the facility.

Measurement and Verification (M&V): The process of using measured data and other operational information to confirm the energy savings from energy efficiency projects. The International Performance Measurement and Verification Protocol defines four standard M&V approaches.

Peak Load: The maximum load during a specified period of time.

Regression Analysis: A statistical technique to describe the relationship between a dependent variable and one or more independent variables. Regression is used for forecasting and prediction across a broad range of applications, including building energy performance monitoring.

Background

The mission of the U.S. Department of Energy's (DOE's) Better Buildings Alliance (BBA) is to transform the way that commercial buildings use energy. Through the BBA, members in different market sectors work with the DOE's network of research and technical experts to develop and deploy innovative, cost-effective, energy-saving solutions that lead to better technologies, more profitable businesses, and better buildings. As of 2015, BBA has more than 200 members representing over 10 billion square feet of commercial building space.

The BBA sector groups include:

- **Private sector:** Retail, Food Service & Grocery; Commercial Real Estate, Hospitality, Healthcare, and Higher Education
- **Public sector:** States, Local Governments, and Public Schools

Members choose from a variety of program activities with the option to participate in 15 solutions teams, including the following:

- **Technology Solutions Teams:** Food Service, Space Conditioning, Lighting & Electrical, Refrigeration, Plug & Process Loads, Laboratories, Energy Management & Information Systems (EMIS), and Renewables Integration
- **Market Solutions Teams:** Financing, Leasing & Split Incentive, Data Access, Appraisals & Valuation, and Workforce Development
- **Public Sector Solutions Teams:** Data Management, Energy Savings Performance Contracts, Financing Strategies, and Strategic Energy Planning

Energy Management and Information Systems (EMIS) are a broad family of tools and services used to manage building energy use. EMIS include benchmarking and monthly utility tracking tools, energy information systems, equipment-specific fault detection and diagnostic systems, building automation systems, and automated system optimization tools. There are a number of recognized benefits of an EMIS, for example:

- Identify efficiency opportunities
- Track & compare performance
- Manage demand charges
- Utility billing validation
- Measure & verify project-specific savings
- Info to ground and set energy goals
- Detect system or equipment faults

EMIS technologies enable 10-20% site energy savings in best practice implementations[1]. The objectives of this EMIS primer are to enable organizations to understand:

- Different types of EMIS technologies and their associated benefits
- Six steps that an organization can take to maximize the success of an EMIS implementation
- EMIS procurement, installation, commissioning, and training issues
- Several aspects of scale-up and evolving EMIS usage over time

The target audience for this primer consists of organizations either considering or in the early phases of implementing an EMIS. This primary target audience includes:

- building owners
- facility managers
- energy and sustainability managers
- commercial property management companies

Secondary audiences that may also benefit from this primer include analysis-as-a-service and managed service providers.

What are EMIS?

Terminology Framework

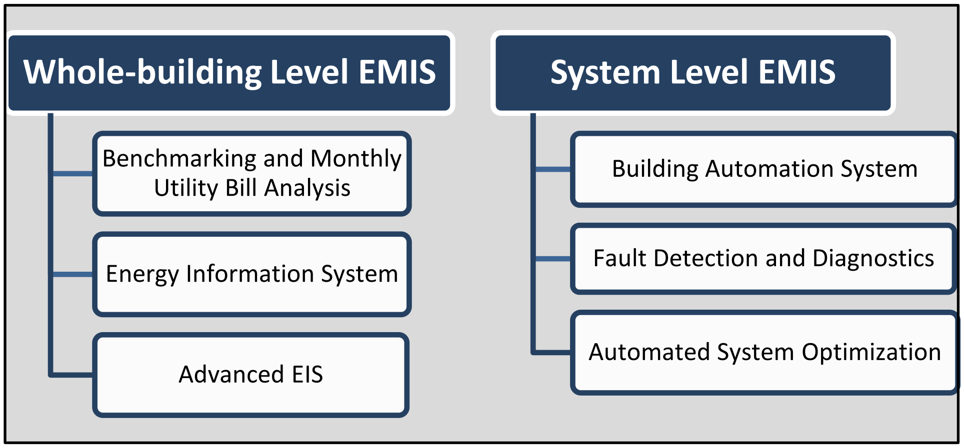
Energy Management and Information Systems (EMIS) are combined hardware and software products that comprise a broad family of tools and services to manage commercial building energy use. The lack of standard terminology for this family of technologies is currently a major barrier to meaningful dialogue and common understanding when stakeholders collaborate. In addition, those new to the domain are often confounded in determining key differences between commercial offerings. The terminology framework that follows was established via consensus across several dozen EMIS vendors, users, and subject matter experts. It provides a common reference that can be used to understand key distinguishing factors and core attributes of different solutions within the family of EMIS technologies.

These technologies include, for example, energy information systems (EIS), equipment-specific fault detection and diagnostic (FDD) systems, benchmarking and utility tracking tools, and building automation systems (BAS). A wide variety of EMIS products are available on the commercial market, and they are increasingly heavily marketed to the energy management community.

This framework can be used as a first orienting step; it does not detail specific technology features, but instead provides a high-level overview of primary applications within each category. Once oriented, users can explore details such as specific feature sets, data integration issues, matching tool capabilities to specific organizational energy management activities, and ultimately, specification and selection.

As illustrated in Figure 1, EMIS can be broadly classified into technologies that are either whole-building focused or system focused. Whole-building-level EMIS includes benchmarking and monthly utility bill analysis tools, EIS, and advanced EIS. System-level EMIS includes BAS, FDD tools, and automated system optimization tools.

FIGURE 1: ENERGY MANAGEMENT AND INFORMATION SYSTEM (EMIS) TECHNOLOGIES[2]



The dividing lines between some instances of these technologies can quickly become blurry; for example, some advanced EIS may offer FDD analytical capability; however, the *principal design intent* of advanced EIS is whole-building or portfolio energy tracking and automated interval data analysis to identify efficiency opportunities. Some offerings may fit into multiple categories.

This framework does not attempt to fit the entire EMIS offering on the market—particularly not those that are most newly emerging and therefore still evolving, in core applications and capabilities. Rather, it frames the majority of commercial offerings. This is a rapidly evolving technology area, and what is true of today's market and today's technologies may be less applicable in the future.

In the following sections, each type of EMIS is summarized according to key distinguishing characteristics:

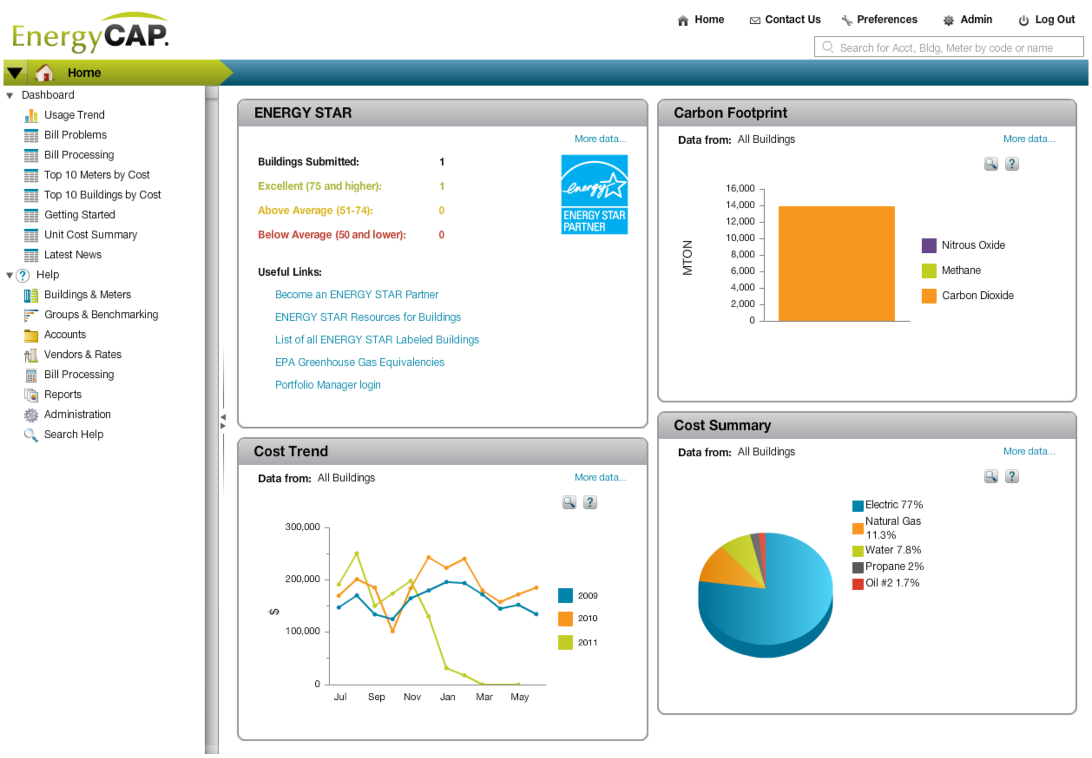
- *Primary applications, principal design intent:* core uses of the technology and user benefits
- *Frequency of use:* how often the technology is typically accessed by the user to gain performance insights
- *Typical data scope:* the level and type of building data that the technology most commonly uses
- *Typical data interval:* the time resolution of the data that the technology most commonly uses
- *May also be referred to as:* other names that might be encountered; these are not necessarily recommended names, but are included to capture terms that may be used in less formal cases, or in marketing materials
- *Vendor examples:* technology examples from the 2015 commercial market; these are representative examples, and are not intended to be an endorsement or comprehensive inventory of market offerings

Benchmarking and Monthly Utility Bill Analysis Tools

- *Primary applications, principal design intent:* utility bill reconciliation, energy use and cost tracking; peer-to-peer building comparisons of energy use
- *Frequency of use:* monthly, annually
- *Typical data scope:* whole-building or campus
- Typical data interval: monthly
- *May also be referred to as*: utility tracking tools, monthly energy monitoring system, billing reconciliation
- *Vendor examples:* U.S. Environmental Protection Agency (EPA) Portfolio Manager, Abraxas Metrix 4, EnergyCAP, WegoWise, EnergyPrint

Benchmarking and monthly utility bill analysis tools use monthly whole-building energy data. They are primarily used for peer-to-peer building energy performance tracking (that is, within the user's portfolio, or nationally, through integration with EPA's Portfolio Manager) or for historical building energy performance tracking, and for validation and management of utility bills. Analyses based on weather normalization may also be offered. Large portfolios or campuses with many utility accounts may use these tools in parallel with EIS and system-level EMIS solutions. Some EMIS offerings accommodate both monthly billing data and interval meter data. The screenshot in Figure 2 show the types of plots and analyses common in benchmarking and monthly utility bill analysis tools.

FIGURE 2: EXAMPLE BENCHMARKING AND MONTHLY UTILITY BILL ANALYSIS TOOL (ENERGYCAP), INCLUDING ENERGY STAR RANKING, CARBON FOOTPRINT, COST TREND DATA, AND A COST SUMMARY



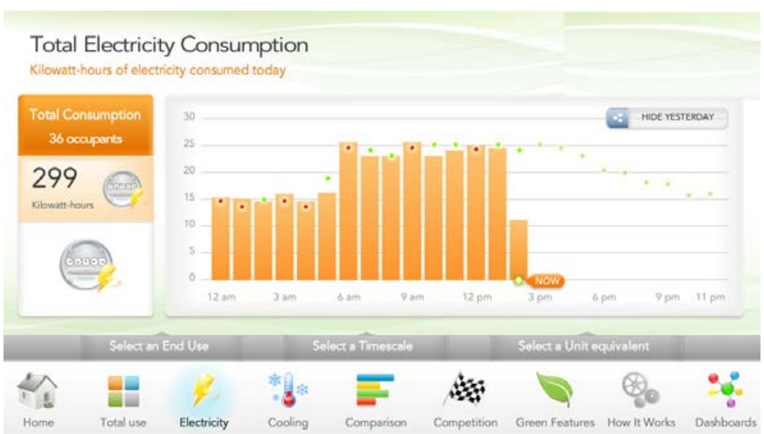
Energy Information System (EIS) and Advanced EIS

- *Primary applications, principal design intent:* whole-building or portfolio energy tracking, data visualization, and automated interval data analysis to identify opportunities to improve building operational efficiency
- *Frequency of use:* daily, weekly, monthly
- *Typical data scope:* whole-building, which may include submetering and system-level monitoring
- Typical data interval: hourly to 15-minute
- *May also be referred to as:* whole-building monitoring system, energy performance tracking system, continuous energy monitoring system, meter visualization tool, energy analytics tool, continuous energy monitoring and analysis system, or enterprise energy management system
- *Vendor examples:* Cascade Energy SENSEI, EnergyICT EIServer, Lucid BuildingOS, EnerNOC, EFT Energy Manager, NorthWrite Energy WorkSite, Mach Energy Insights, eSight Enterprise

Energy Information Systems (EIS) are broadly defined as the web-based software, data acquisition hardware, and communication systems used to analyze and display building energy performance. At a minimum, an EIS provides daily, hourly or sub-hourly interval meter data at the whole-building level, with graphical and analytical capability. The data is primarily acquired from whole-building electricity and gas meters, but can also include sub-meter and system-level data depending on the depth of monitoring at the site. External data sources such as time-series weather data, energy prices, and demand response information may be integrated into the EIS to enhance its analytical capabilities. More sophisticated EIS implementations may also integrate trend log data from building automation systems to provide insight into system operations.

Basic EIS features include data visualization or dashboard viewing; portfolio, building, or sub-meter energy tracking; time series load profiling; and peak load analysis. More advanced EIS offerings provide a higher degree of automated analytics, in combination with baseline models that are used to normalize for key energy drivers such as weather and time of week. These models are then used to conduct automated energy anomaly detection, project savings verification, and cumulative sum of aggregated energy savings overtime. Figure 3 shows a screenshot of an EIS dashboard page.

FIGURE 3: EXAMPLE EIS SCREENSHOT (LUCID), A BAR GRAPH TRACKING ENERGY CONSUMPTION PATTERN AT AN HOURLY INTERVAL



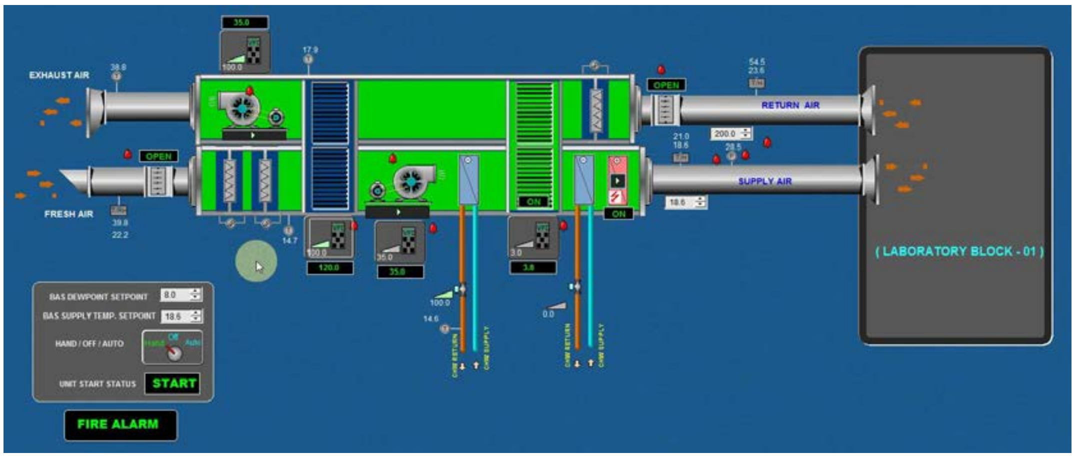
Building Automation System

- *Primary applications, principal design intent:* control of indoor temperature, light, and humidity setpoints based on building schedule, and alarming of out-of-range operations
- *Frequency of use:* daily, weekly, monthly
- *Typical data scope:* systems, components, may include submetering
- Typical data interval: 15-minute and less
- *May also be referred to as:* energy management and control system, building management system, energy management system, and building control system
- *Vendor examples:* Automated Logic WebCTRL, Siemens APOGEE, Johnson Controls Metasys, Novar Opus EMS, Tridium Niagara

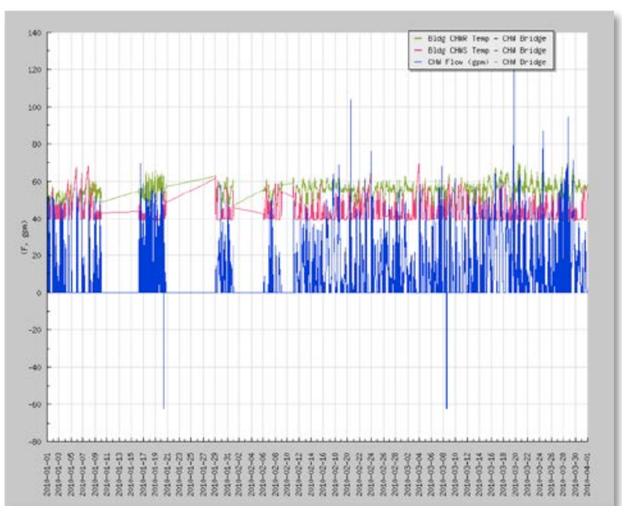
Building Automation Systems (BAS) are used to control building heating, ventilation, and air-conditioning (HVAC) systems, and in some cases building lighting and security systems. They are the most widely adopted technology in the EMIS family, and are implemented in most large and medium-sized commercial buildings. The primary purpose of a BAS is to maintain indoor temperature, humidity, ventilation, and lighting conditions. Modern BAS also offer significant trend logging, storage, reporting, and visualization capabilities. These time series data trends can therefore be used to view and troubleshoot system-level or equipment-level performance. They can also be used to track key performance metrics related to both energy management and routine operations; for example, cooling plant efficiency (kilowatts [kW]/ton) and ventilation efficiency (watts per cubic foot per minute [W/cfm]). While system-level operational parameters are most common, some BAS integrates electricity meters. Figure 4 shows two screenshots common to BAS: on the top a graphical representation of an air handling unit (AHU) with real-time sensor status, and on the bottom, a multi-point overlay of chilled water flow and supply and return temperatures.

Some of the newer wireless sensor technologies that detect pressures, temperatures, humidities, etc., can, and are beginning to be integrated into existing monitoring and control architectures. WiFi and ZigBee solutions, for example are being explored in combination with BAS, and other types of EMIS technologies. These new technologies may be embedded into HVAC and lighting systems and components.

FIGURE 4: (a) EXAMPLE BAS SCREENSHOT (SIEMENS) OF AN AHU WITH SYSTEM PARAMETERS; (b) EXAMPLE BAS TREND GRAPH (AUTOMATED LOGIC) SHOWING CHILLED WATER SUPPLY AND RETURN TEMPERATURES, AND FLOW, 5-MIN. SAMPLES



(a)



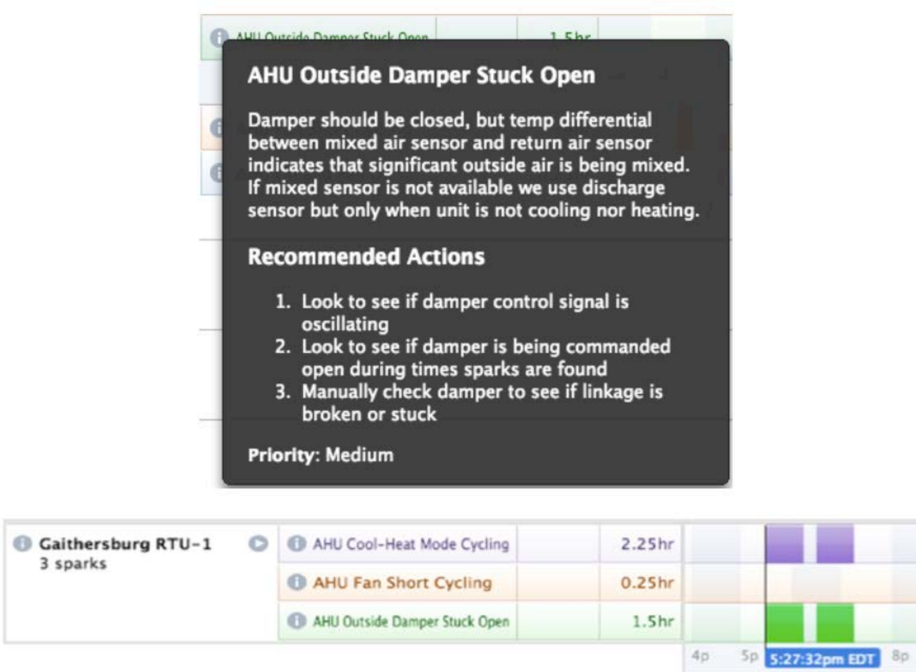
(b)

Fault Detection and Diagnosis Tool

- *Primary applications, principal design intent:* automated identification of faults, sometimes with associated causes, usually HVAC focused
- Frequency of use: weekly, monthly
- *Typical data scope:* systems, components, BAS trends; may include whole-building or system-level submetering
- Typical data interval: 15-minute and less
- *May also be referred to as:* system monitoring and analytics, ongoing or monitoring-based commissioning systems
- *Vendor examples:* Johnson Controls Panoptix, Schneider Electric Building Analytics, KGS Buildings Clockworks, Cimetrics Analytika Pro, SkyFoundry SkySpark

Fault Detection and Diagnostics (FDD) tools automatically identify HVAC system or equipment-level performance issues, and in some cases are able to isolate the root causes of the problem. These tools typically integrate data from building automation systems, and may include submeter and whole-building energy data. Commercial FDD tools commonly use three methods to detect faults: (1) rules, (2) like-equipment comparisons, (3) models that characterize typical performance based on historical operational data. FDD tools may provide a report of the duration and frequency of faults, cost and/or energy impacts, and relative priority levels. They usually provide a number of possible causes or recommendations for correcting each fault, requiring either additional data analysis by the user or on-site inspection. Figure 5 provides a screenshot from a commercial FDD tool.

FIGURE 5: EXAMPLE SCREENSHOT (SKYFOUNDRY) OF A FDD TOOL, SHOWING FAULTS AND RECOMMENDED ACTIONS



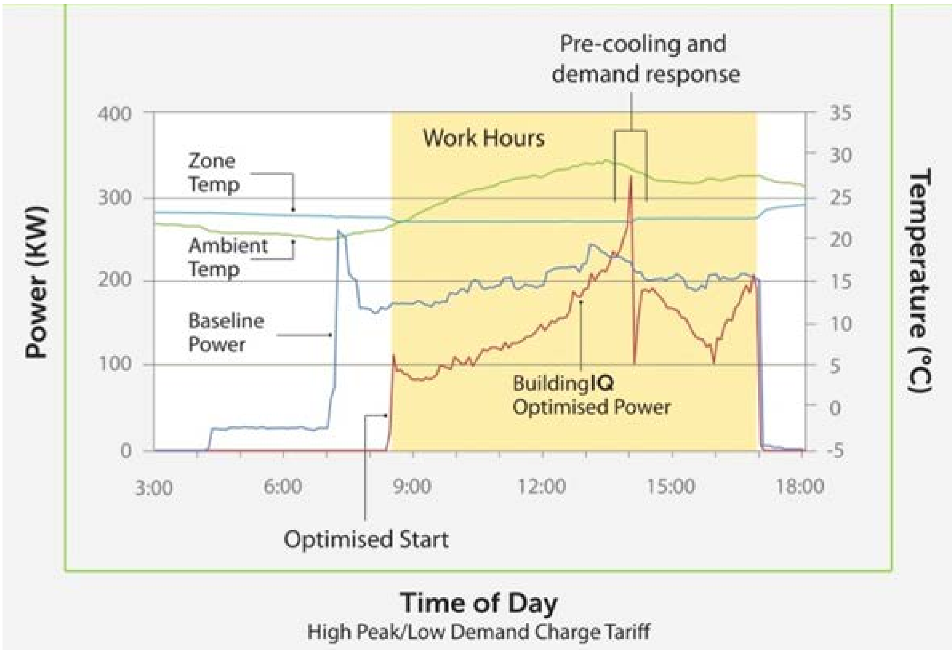
Automated System Optimization Tool

- *Primary applications, principal design intent:* automated modification of control parameters to optimize efficiency, energy use, and/or energy costs
- Frequency of use: weekly, monthly
- *Typical data scope:* systems, components, BAS trends; may include whole-building or system-level submetering
- Typical data interval: 15-minute and less
- *May also be referred to as:* control optimization software, continuous optimization, automatic energy optimization systems
- *Vendor examples:* BuildingIQ, Enerliance LOBOS, Optimum OptiCx

Automated System Optimization (ASO) tools dynamically modify building automation system control settings to optimize HVAC system energy usage while maintaining occupant comfort. Two-way communication with the BAS is the distinguishing feature of ASO solutions. These tools both read data *from* the BAS and write analytically based optimal setpoints *back to* the BAS, based on measured indoor, outdoor, and energy price conditions. The optimized target is typically the minimum energy use, cost, or demand of the whole system (e.g., chiller plant system, air handler system) rather than the highest efficiency of individual equipment (e.g., cooling tower, supply fan in the air handler). For example, an ASO tool may determine a day-ahead optimal start time for a chilled water pump based on weather and load forecasts, with an objective to minimize total plant energy use. Other examples of control settings that may be manipulated in ASO tools include chiller chilled water supply temperature, air handler duct static pressure, and thermostat cooling and heating set-points. ASO technologies are the newest in the EMIS family, with a limited number of commercial offerings and users, relative to other EMIS types.

Figure 6 shows an example of an ASO tool used to optimize HVAC system operations during a typical day. The blue line shows the (modeled) power consumption that would result from the standard control sequences programmed into the BAS. The red line shows the measured power consumption under the ASO's supervisory control. The morning start-up is adjusted to account for the current day's weather and low overnight ambient temperature the prior night. Other control set-points are also reset throughout the day, to reduce the power use compared with the standard BAS settings. In addition, the system is controlled to pre-cool the building in the afternoon, to avoid high demand in the peak electricity rate period.

FIGURE 6: EXAMPLE (BUILDING IQ) OF HOW AN ASO TOOL WORKS ON AN HVAC SYSTEM IN A TYPICAL BUILDING DURING A TYPICAL DAY



Benefits for Each Type of EMIS

Using an EMIS to track energy metrics provides a number of benefits, including finding and fixing problems more quickly, ensuring efficiency investments pay off, and recommending energy performance improvements. EMIS also gives organizations an overall better understanding of energy use. Each of the different types of whole-building-level and system-level EMIS have certain technology attributes and benefits. Table 1 summarizes the benefits, energy savings, and costs of each EMIS type.

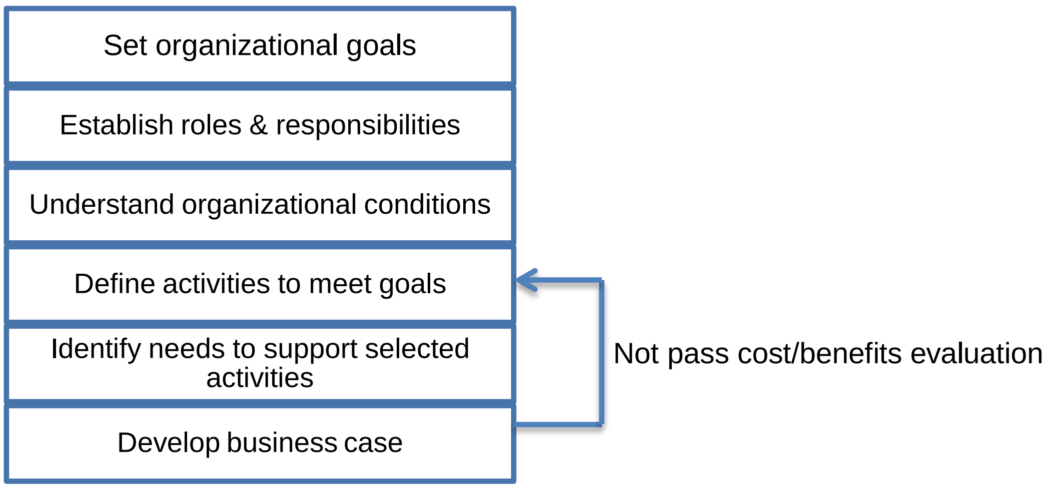
TABLE 1: SUMMARY OF EMIS TOOLS

EMIS Type	Benefits	Energy Savings	Costs
Benchmarking and Monthly Utility Bill Analysis	▶ Offers peer to peer energy performance comparisons ▶ Provides insight into whole-building energy performance ▶ Assists in streamlining bill payment processing	Average annual energy savings of 2.4%[3]	Free or $
Energy Information Systems (EIS) or Advanced EIS	▶ Provides granular energy consumption history and patterns ▶ Notifies user when energy exceeds expectation ▶ May normalize for weather and other factors ▶ Enables identification of operational energy efficiency opportunities	Median annual portfolio savings of 8% Range in annual portfolio savings of 0%–33%[1]	$$–$$$
Building Automation System (BAS)	▶ Improves system operations and energy use, and maintains occupant comfort by regulating indoor conditions	10%–15% result from installation of a new BAS[4]	$$$$
Fault Detection and Diagnosis (FDD)	▶ Identify HVAC system- or equipment-level faults and sometimes isolate root causes ▶ Early identification of faults can prevent mechanical failure, extending equipment life ▶ Reduce energy costs and equipment wear-and-tear	2%–11% (whole-building, potential savings)[5]	$$$
Automated System Optimization (ASO)	▶ Dynamically change HVAC BAS settings to optimize energy use and comfort		$$$

EMIS Planning

Planning for an EMIS requires an organization to set organizational goals, establish roles and responsibilities, understand organizational conditions, define the activities to meet those goals and developed business case. Figure 7 provides a diagram of the key steps in the EMIS planning process. The planning effort should specify what information will be collected, how it will be used (and by whom), how often it will be used, and how it will be acted upon.

FIGURE 7: EMIS PLANNING PROCESS



The information and insights gained through the use of an EMIS can be relevant to different departments within an organization, so it requires working with stakeholders across the organization to plan. As a simple example, energy managers may leverage technology features to track utility cost savings from efficiency projects, which can also be reported to financial business units. It is also necessary to give attention to the number of metering points and the physical and sensing infrastructure necessary to support activities to meet driving organizational goals.

Also, innovative planning can look outside of the traditional model of using legacy BAS vendors to explore new technologies with Internet of Things (IoT) and automation developers. In many cases, there are new solutions from non-traditional HVAC-BAS vendors that incorporate the latest smart devices with new apps using open protocols at significant cost savings.

The planning process that is presented in this section can be applied to both existing as well as new buildings, however many of the detailed guidance is most relevant to existing buildings, campuses, and portfolios. The process of designing an EMIS for new facilities would be integrated with the design of mechanical, electrical, and building automation components. Including consideration of the analysis and monitoring infrastructure and technologies throughout the building and controls design process can minimize costs and maximize effectiveness.

Set Organizational Goals

When establishing organizational goals, first identify the business problem that the EMIS is going to solve, and then determine which goals will address those challenges and assign a timeframe for achieving them. Some examples of organizational goals include: lowering energy use by 20 percent over the next three years, achieving a building energy use intensity (EUI) of 70 thousand Btu per square foot (ft^2) per year, or achieving a U.S. Environmental Protection Agency (EPA) ENERGY STAR rating of 75. Organizational goals may also focus on tenant/occupant comfort, carbon reduction, or operational cost reduction. Some goals are absolute (like a 20 percent reduction in energy use in a year) and some are relative (like a reduction in carbon per employee). It is also important to scope out appropriate and realistic target dates for goals, be they short-term (quarterly, annual) or longer term (3–5 years), and the different factors that shape these goals. Often, projects are overlooked because the short-term payback is not strong enough. However, if the same goals are looked at over a longer time frame the savings can be significant. Energy goals can take various forms in terms of units and scope. Examples of typical energy targets are as follows:

- **Demand Side versus Supply Side:** A demand-side energy target emphasizes energy use reduction; whereas, a supply side target may consider market-based procurement opportunities in deregulated markets or establishing goals for renewable energy vs. carbon-intensive fossil fuel generated energy.
- **Energy Consumption versus Peak Demand:** An energy consumption target is useful to help reduce costs and/or greenhouse gas emissions by establishing goals for lower use. While an alternative or additional goal is to establish a peak demand reduction target or a peak load shifting target. Peak demand occurs at certain times in the year and can have a significant impact on energy costs. Many utilities will impose peak demand charges that escalate with higher peaks. Utilities with time-of-use and other pricing programs may offer incentives for use of electricity during low demand or off-peak periods. Load shifting can take advantage of these incentives by moving building energy loads from on-peak periods to off-peak periods.
- **Whole-building versus Subsystem:** A whole-building target looks at whole-building energy consumption while subsystem targets are used to draw attention to energetically important systems such as chiller plants, data centers or laboratory spaces.
- **Absolute versus Normalized:** A goal could be set up based on absolute energy consumption information or normalized energy consumption. Absolute energy consumption is good to use when creating a baseline. Normalization considers relationships between variables and is a method to increase the comparability and relevance of energy consumption data. Normalization creates a level playing field that avoids comparing different quantities.

No matter what set of goals are decided upon, the goals should be:

- **Specific** (one number that is relevant at the site and agreed upon by the team)
- **Measurable** (measurable at the site and reported with minimal external data)
- **Inclusive** (accounting for all loads associated with the organization)
- **Appropriately aggressive** (have an impact on design and operations)
- **Timely** (have a target timeframe for completion)

EMP and EMIS Planning

An energy management program (EMP) is a program by which an organization establishes processes to achieve control and improvement of energy performance – a systematic approach to energy management. The EMIS collects data that supports very many aspects of the EMP (the energy review, the calculation of an energy baseline, energy performance indicators, and to verify the action plan results). Setting goals and establishing roles and responsibilities of stakeholders are two key steps in both EMP and EMIS planning.

To learn more about how to effectively set goals and establish roles and responsibilities, consider the ***ENERGY STAR Guidelines for Energy Management*** (http://www.energystar.gov/buildings/tools-and-resources/energy-star-guidelines-energy-management) and ***ISO 50000 Energy Management Standards*** (http://www.iso.org/iso/home/store/catalogue_tc/catalogue_tc_browse.htm?commid=558632)

Before establishing clear, measurable goals, it is important to know what is achievable in your facility or portfolio. Some ways to do this include creating a baseline, benchmarking, evaluating past projects and best practices, and conducting technical audits[6]. Federal or state mandated targets for reduction of energy use, water use, and carbon emissions could be considered in this process. It is also advisable to determine the relative magnitude of annual expense that is committed to energy. In some organizations it may be a very high percentage of operating expenses while at others it may be a relatively low percentage. Understanding this will help make the case for investment in an EMIS.

Once you have estimated the potential for improvement, establish clear goals for the organization. The baseline and benchmarking activities will provide a starting point. Goals can be defined in the following ways:

- **Setting a reduction target:** Here a percentage decrease in energy use is established, such as 10% reduction or net zero target. Include the timeframe for achieving the target
- **Ratings:** This goal sets the organization to achieve a particular performance rating, such as a LEED certification or ENERGY STAR rating
- **Efficiency Improvements:** Goals can be expressed as a function of recognized energy metrics, like reducing energy use intensity (EUI) or reducing energy intensity of a performance indicator, such as 2 Btu per unit of product

Organizational Goal Setting Example - UC Merced[7]

Description: The University of California used an organization-wide, or strategic energy management approach to setting building energy targets for its new Merced campus. Well in advance of acquiring buildings for this campus, the university performed statistical analysis on "business-as-usual" energy data for common building types across the organization[8]. A goal of 50% improvement from the benchmarked energy use was set but phased in over the construction timeline: 80% to start, then 65% of benchmark once the 80% target was proven successful. The 50% target was introduced for the more recently constructed buildings. For each building on campus, the relevant percent of benchmark was the starting point for the organization's energy managers to set EUI-based energy targets and peak demand targets at the building and campus levels. The benchmark-based targets were normalized for climate and building type, and were set for electricity, gas, and district heating and cooling. This is an example of organization-wide goal setting within a strategic energy management program.

Establish Roles and Responsibilities of EMIS Users and Stakeholders

Once you have determined organization-specific goals for use of the EMIS, engage key stakeholders from both management and operations to establish roles and responsibilities for its use. Executive sponsors are critical to the success of the implementation and it is good to engage them early. It is likely that they will need to sign-off on potential cost of the system. It is good to establish who will use the EMIS and in what capacity to reach the organizational goals and to provide organizational informational value. A team or a staff member must be appointed to use the tool daily, weekly, monthly, or annually to ensure that EMIS data are creating value for the organization. If resources permit, set up a small group, like a technical committee, within the organization. This group will "own" the system and make the ultimate decisions, which is a great way to engage your organization and get support for the system. For larger organizations, consider using a third party to facilitate conversations. Key organization stakeholders that would play a role in the EMIS could be procurement, IT, legal, and finance, but others could be involved as well. Including these stakeholders early can prevent months of delay once a decision to procure an EMIS has been made.

When determining EMIS access, consider the following factors:

- **Frequency of use:** How often will the operations staff access the EMIS to identify savings? Daily, weekly, monthly, or annually?
- **Setup standard operating procedures:** What will the standard operating procedures be once savings have been identified? For example, if the number of hours that lights operate needs to be reduced to achieve savings, which key stakeholders must be notified for that to happen?
- **Data review by key stakeholders:** How often will the data from the EMIS be reviewed with senior management or key facilities staff?
- **Alarms and push notifications:** What thresholds should be established to cause an alarm and/or push notification via email or text messaging?

Identify internal roles. Personnel who may be involved internally could include, but are not limited to:

- Senior executive
- Facility managers
- Energy manager
- Finance
- Information technology
- Environment, health and safety

Identify external roles. External parties that may be involved are:

- Consultants
- Vendors and service providers

Successful EMIS implementations typically have a strong internal technology champion who supports and encourages regular use of the tool throughout the organization. At the facilities and operational level, staff roles and responsibilities should be aligned with use of the tool, and sufficient time allocated to permit a thorough data review. Management can encourage proactive use of the data by: (1) including EMIS analyses in regular operational and energy management tasks, and (2) taking leadership in instilling a performance-based, data-driven approach to operations. Similarly, executive staff can incorporate EMIS information into regularly viewed reports and hold the organization accountable for energy performance. Enterprise-wide EMIS use and shared energy awareness is key for maximum impact.

Understand Organizational Conditions

Understanding existing building and information infrastructure, as well as personnel considerations, are critical steps in the EMIS planning process. This section explicitly defines and documents building characteristics, assets and systems, and organizational energy management procedures and staff. This information is necessary to link the organizational energy management goals to specific activities to meet the goals, and therefore associated technology attributes.

Building Characteristics

To begin, the project manager should first record the characteristics of the targeted EMIS implementation sites. The following material shows the building characteristics that should be known and related issues that need to be considered in the EMIS planning process.

Characteristics	Considerations
Building type	Building performance metrics that are monitored and tracked using an EMIS are different for different building types. For example, energy use intensity (EUI, e.g., KBtu/ft^2/yr) is a common metric for all building sectors. Power usage effectiveness (PUE), the ratio of total energy use to that of IT equipment, is the main energy efficiency metric for data centers. For hotels, number of rooms or occupants may be critical factors to normalize, and interpret energy use. Building type also influences the diversity and distribution of energy end-use loads and equipment types. Finally, EMIS vendors may have more experience or work history serving specific commercial verticals (office, higher education, hospital, food service, etc.).
Number of sites	Implementation of EMIS for a large portfolio of buildings is different from that for a small number of buildings. For large portfolios, enterprise reporting and visualizations are important. The number of sites will also impact the scope and timing of the eventual technology deployment effort. Geographic diversity may influence technical considerations such as comparative analyses that require weather normalization, diversity in utility regions and tariffs, and the diversity of HVAC systems being operated.
Tenants condition	Benchmarking mandates require the owner of each building report energy usage data (and in some cases, water usage data) to the city on a regular basis. In instances where utility providers can't disclose data directly to landlords, the landlords need to obtain energy and water use data from tenants.
Utility costs	Facility and portfolio and individual building energy spend, to some extent, determine the potential benefits from investing in an EMIS. The potential energy cost savings from EMIS should justify the upfront and ongoing costs (and usually do, given the significant opportunities for operational efficiency), and the benefits of improved efficiency and persistent savings over time must align with organization's financial investment practices.
Utility tariffs	Site-specific utility tariffs are useful inputs for EMIS to calculate and provide visualizations of accurate real-time or historic energy costs. Some tools may be able to provide an internal representation of the specific tariff structure for your utility.

Building System Information

In designing an EMIS, carefully consider how it will be leveraged into existing building systems. The planned EMIS should use existing infrastructure as much as possible. For example, some sites may already have interval meters which can be directly integrated into the EMIS, reducing project costs. A list of existing metering and monitoring infrastructure in the request for proposals (RFP) will provide proposers with key aspects of the project scope and estimated project costs. Table 2 shows the items of building systems that should be surveyed in the EMIS design process.

TABLE 2: ITEMS TO IDENTIFY IN BUILDING SYSTEMS FOR EMIS PLANNING

Existing Metering System	Existing Building Automation System (BAS)	Other
▶ Meter type (fuel measured, and make and model) ▶ Meter functionality (can it communicate to external monitoring and control systems?) ▶ Meter location (what loads are downstream of, or captured in, the meter readings) ▶ Meter accuracy ▶ Data interval ▶ Data communication protocols ▶ Availability of historical data and storage location	▶ Make and model ▶ Points list ▶ Sequences of operation ▶ Data communication protocols ▶ Any centralization or Internet access to the system ▶ Availability of historical data, ability to access trend log data from historian ▶ Trend logs currently used/viewed by operators	▶ Data storage software and hardware ▶ Other data sources, monitoring and diagnostic systems, (e.g., power quality or energy/fault analytics systems, variable frequency drives)

To identify a building's existing electric metering, review the electrical drawings—especially single-line drawings (or *power riser drawings*) and panel schedules. Electrical single-line drawings graphically depict the paths for power flow through the electrical switchboards to bus bars to panels. They show the number and location of installed meters. Panel schedules provide a detailed load description (e.g., lights – room 101, air condition handler -1, and chiller -1) of each circuit in the panel. Combining the information from electricity drawings, an EMIS planner can understand which building loads are captured in existing meters, as well as considerations such as the number of sub-meters that might be required to monitor and track energy use at the system level (e.g., HVAC, lighting, and plug load).

When other meters such as gas meters, steam meters, and thermal meters or water meters are considered, mechanical schedules and piping diagrams are critical. Mechanical schedules list all the components in the HVAC system, and their specification parameters. Piping diagrams (also known as *flow diagrams* or *riser diagrams*) such as a chilled water or heating water piping diagram show the availability of gas, steam, and thermal meters, and can be used to determine potentially where these meters should be installed to capture the desired building loads, and meet installation specifications.

If a more sophisticated EMIS (e.g., automated system optimization tools or EMIS with fault detection and diagnostics capability) that requires integrating BAS trend logs is being considered, you need control drawings that show the BAS control points and sequence of operation, to understand the existing control strategy and facilitate the point mapping between the BAS and the planned new EMIS.

In many cases, mechanical and electrical drawings will be incomplete or outdated, particularly for older buildings or those that are not as well maintained. A site visit to access and verify actual current conditions is highly recommended. This site visit may be conducted by the EMIS planner or by the vendor who is contracted in later stages to conduct the EMIS implementation.

Organizational Energy Management Procedures and Staff

Energy management and information systems are tools primarily used by energy managers, facility managers, or operators to support organizational energy and management and operational practices. The purpose of understanding current energy management procedures is to gain insight on how the organization typically documents and manages energy information and consumption. This knowledge provides insight as to how the EMIS could fit into the standard energy management architecture and streamline the daily energy management process. For example, if the organization currently produces spreadsheet-based, yet standardized, energy performance summary reports, EMIS that offer customizable reporting features could streamline associated labor time and cost while maintaining continuity with current practice.

The following questions are examples of aspects of energy management procedures that should be considered for continuity and enhancement through use of the EMIS:

- What are the organization models for managing energy? Some organizations assign one individual to lead all energy management tasks. Others have energy management groups that consist of representatives from different departments, such as engineering, maintenance, and utility accounts payable. Other models may feature a headquartered position for energy and sustainability management, with local site-level building operators who may or may not report to the central energy manager. In addition, energy service providers may be contracted for specific project functions. Understanding the model that is in use will help determine the most effective means to integrate the EMIS vertically and horizontally throughout the organization.
- How much staff time is allocated for energy management activities? What is the human resource level in terms of full-time staff equivalents?
- Are there performance incentives in place that relate to energy, operations, or maintenance?
- What are the “standard operating procedures” (work request system, authorizations, etc.) that are in place to enable both capital and operational improvements once an opportunity is identified?
- Is there periodic review of energy performance? If yes, what are the review contents and frequency? What is the chain of accountability?
- What reports are currently used in energy management practices? What information systems, metrics, time horizons, and data sources are used to generate those reports? Who receives and reads the reports?
- Is any information on energy performance presented to external stakeholders or reporting agencies (e.g., project savings, emissions, ENERGY STAR Scores)?

Energy management and information systems are not efficiency equipment, but rather human-in-the-loop tools. Therefore, a well-resourced, knowledgeable team must be engaged with them to enable energy savings. Understanding the skills and current responsibilities of in-house staff is critical to maximizing EMIS benefits and determining which functions are ideal for in-house delivery versus service-based delivery. The following items should be considered when evaluating staff capacity.

- Awareness of the roles they can play in reducing the energy consumption of the building components or items under their direct/indirect control
- Knowledge of federal, state, and local building regulations, codes, standards, and best practices
- Ability to analyze and interpret quantitative energy and operational data, and visualizations
- Training, expertise, and familiarity with the characteristics of building systems and equipment, as well as efficiency measures
- General experience using information and analysis technologies
- Degree to which energy management is explicitly represented in staff position descriptions, roles, and responsibilities
- Staff decision-making authority relative to building operational parameters, setpoints, schedules, etc.

Define Activities to Meet Goals

To specify an EMIS, its capabilities or uses must be established in advance. Planning for an EMIS requires an organization to set organizational goals, establish roles and responsibilities. These goals can only be achieved with specific actions. The inventory or understanding of building and system characteristics, as well as an organization's energy management procedures and staff resources can be used as information to ground the definition of these specific actions. This section defines the specific EMIS-based activities that help meet an organization's goals. The following list of activities are examples that different internal stakeholders may wish to support through EMIS use that collectively may contribute to the organization's goals. Note that depending on the organization, these stakeholder roles may be handled by multiple individuals; conversely, multiple roles may be handled by a single individual.

- Executives
  - Building energy dashboard: provide public energy dashboards to display *performance for executive manageme*nt; dashboards also provide useful at-a-glance information to other stakeholders such as the public, and energy or sustainability managers
  - ENERGY STAR interface: automate data transmission and facilities' certification with EPA ENERGY STAR Portfolio Manager
- Utility Bill Manager
  - Utility bill allocation: allocate utility costs to different tenants or occupant groups sharing a building according to actual energy usage
  - Utility bill validation: detect potential billing errors
  - Utility budgeting: forecast future energy use and utility costs
  - Automated bill payment, or streamlined account processing

- Sustainability Manager
  - Renewable energy tracking: monitor and track units of renewable energy consumed on site
  - Greenhouse gas (GHG) tracking: calculate, monitor, and report site GHG emissions complying with any associated regulation requirement
- Energy Manager and Field Engineer
  - Cross-sectional benchmarking: compare energy consumption with similar buildings, prioritize buildings for efficiency improvements
  - Efficiency project management: log and track the status of energy efficiency projects (e.g., start, ongoing, finish), and descriptions of measures and expected savings
  - Measurement and verification: establish baseline energy use and post-project energy use to determine the efficiency project savings
  - Peak load analysis: identify peak demand and hours at the site level
  - Regular performance review: conduct a monthly meeting to review building performance
  - Energy tracking: monitor and track the energy consumption and intensity at the site, system, or major energy-consuming equipment level
  - Load profiling: inspection of 24-hour periods of interval meter data to understand the relationship between energy use and time of day, and contributions of large energy consuming equipment to total building load
  - Longitudinal benchmarking: compare energy usage for a site, system, or equipment component against past performance
  - Energy anomaly detection: identify and flag unexpectedly high or low energy use
  - System/equipment fault identification: detect operational faults in systems or equipment, with recommendations to guide investigation and resolution
  - Portfolio reporting: provide regular energy, cost, or equipment health reports
  - Goal tracking: tracking organization goals on reduction of energy consumption or costs

Organizational EMIS Activity Case Example

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Activity: Identify end-use systems' energy performance issues

Primary audience: Building engineer

Description: The building engineer responds to real-time power (kilowatts) and energy (kilowatt-hours) relative to hourly expectations

Success scenario:

- For each hour of the year, the EIS determines the expected energy use of each end-use system from regression or other data-driven baseline modeling results
- Real-time power and energy data are displayed with respect to the expected operating range
- The energy engineer can open the "energy dashboard" and determine in less than one minute whether each end-use is performing as expected

One effective means of documenting EMIS activities is to summarize each activity in a consistent format. For example, each activity summary includes an activity name and description, the staff involved in the activity (primary audience), and more specific requirements (success scenario).

Although this step may result in multiple activities needed to fulfill the scope of EMIS after the first round of discussion, the intent is to demonstrate a full picture across the organization, considering potential functionalities enabled by the EMIS. These activities need to be prioritized based on the resources and staff time available. When prioritizing activities, note that they may not all be able to be covered by a single EMIS solution.

Identify Needs to Support Selected Activities

Once the EMIS activities are selected after prioritization, determine what needs are necessary for supporting the targeted activities. There are data needs, equipment needs, and security needs.

Each activity requires certain types of data. For example, to verify the project savings, it is necessary to have the interval energy data (e.g., electricity and natural gas) of the whole-building or of a specific system that the project impacts. In addition, weather data such as cooling or heating degree days are needed to adjust the influence of weather to energy consumption. Table 3 shows some examples of specific data elements necessary to support the activities.

TABLE 3: EXAMPLE DATA REQUIREMENTS

Activity	Data Type	Minimum Resolution
ENERGY STAR Portfolio Manager benchmarking	Whole-building energy use	Monthly
	Gross floor area, ZIP code, building type, year of construction, # of workers on main shift, # of personal computers etc.[10]	n/a
Utility bill validation	Utility bills, EMIS metered whole-building or account-level energy use, EMIS metered demand (if time-of-use rates applied)	Monthly (from utility bills) or hourly (if interval data are available)
	Utility tariff	n/a
Portfolio specific benchmarking	Whole-building energy use	Annual
	Gross floor area, ZIP code, building type, and year of construction	n/a
Measurement and verification	Energy and demand, weather condition (outside air temperature or degree days)	Based on depth of savings and M&V accuracy requirements. Monthly, hourly, and sub-hourly data may be used depending on the project and data availability
Demand management	Whole-building electric	15-minute
	Building floor area	n/a
Greenhouse gas (GHG) tracking	Energy use	Monthly
	GHG emission conversion factors	n/a
Whole-building load profiling	Whole-building energy use	Hourly or sub-hourly
Energy tracking of major energy-consuming equipment	Sub-metered energy use at the end-use or equipment level	Hourly or sub-hourly
Energy anomaly alarming	Energy use, weather condition (outside air temperature or degree days)	Hourly or sub-hourly
System/equipment fault identification	Depends on the targeted system; usually includes temperature, flow rate, on/off status, and pressure measured from sensors	15 minutes or a shorter interval
Regular reporting	Depends on reporting requirement, energy and demand for consumption-related reports, prioritized issues for operation-related reports	Depends on reporting requirement

Metering needs will depend on the data type for each activity, and the existing monitoring infrastructure documented in the step of “Understand Organization Conditions”. New equipment such as meters, sensors, and data acquisition hardware may be needed in addition to the EMIS software. This equipment is usually installed with the EMIS and commissioned at the same time the EMIS is configured; over time, additional metering can be added and integrated into the system. As mentioned in the Building System Information section, electrical and mechanical drawings are a useful resource to determine the number, location, and measurement range (e.g., 1,600A, 480V, 3 phase) of new meters. Measurement range and accuracy are key parameters to specify for sensors and meters used for monitoring and continuous analysis. Several types of electric meters and natural gas meters are available from many manufacturers. Appendix A summarizes the most common meter types, capabilities, common applications, and costs. Lawrence Berkeley National Laboratory has more discussions on key performance metrics for performance monitoring and associated meter and sensor requirements.

Meter and sensor data are transmitted to data servers or the cloud via a data acquisition system. Data acquisition hardware such as gateways, repeaters, and cables are needed if there are no existing items in place; these can be selected and implemented by the service provider that deploys the EMIS. A common strategy to simplify the process is to specify the desired metering capabilities and rely upon the provider to design and implement the metering and data acquisition system. Due to budget constraints, upfront procurement of all desired and preferred functionalities and hardware may not be a practical option. Therefore, when identifying data and equipment requirements, consider future potential needs and scalability.

In addition, data and network security is an increasingly important aspect of business information systems. Secure access and communications should be ensured to protect the data and reduce the risk of vulnerability. To assist in ensuring sufficient security measures are in place, involve representatives from the organization’s information technology (IT) departments early in the EMIS planning process.

Build a Business Case

The business case justifies to management the cost benefits associated with EMIS implementation. Often, management needs assurance that the investment will pay off based on enabled energy and utility cost savings.

Key points to help you structure the business case include:

- **Articulation of the business need for the EMIS**
- **Desired outcome:** Unique value proposition for the organization through the adoption of EMIS
- **Cost-benefit analysis:** Costs required, payback period, return on investment, energy-efficiency improvement potential and utility cost impacts, and labor reductions associated with process streamlining
- **Organizational Impact:** Indirect financial or non-monetary benefits

Clear and measureable goals can be used to convince stakeholders about the value of investing in an EMIS and can also be used to communicate goals to motivate staff. The business case should relate to the overarching organizational goals that are developed for the organization.

EMIS costs can be broken into hardware and software costs. The hardware costs include additional required metering, submetering or sensors, investigation of security issues, installation costs, data communication and/or storage costs, and whether a local server is needed at each location. Software costs are most often broken into a single upfront cost and a recurring ongoing cost that is usually assessed annually. Upfront costs cover software licensing and initial system installation, configuration, integration, and training fee. Ongoing costs are charged for technical support, system usage, service, and maintenance with diverse frequency (e.g., monthly, quarterly, or annually) and according to diverse measures (e.g., per building or a single annual fee). Cost drivers include the complexity and extent of hardware and software components, scale of the implementation, and the degree of customization required. The costs of different types of meters (e.g., electric meter, natural gas meter) are readily available in the publications[11]. The costs of EIS software are studied in *EIS Technology Costs, Benefits and Best Practice Uses*[12], and the results are shown in Table 4.

TABLE 4: MEDIAN EIS SOFTWARE COSTS: UPFRONT, ONGOING, AND 5-YR TOTAL COSTS OWNERSHIP

Type of Costs	Median			
	$	$/monitoring meter point	$/building	$/sf
Upfront	23,000	230	1,400	0.01
Ongoing (per year)	16,000	200	400	0.01
5 yr. ownership	150,000	1,800	3,600	0.06

Financing EMIS Projects

To learn more about the types of incentives available to offset first costs, consider the ***Regional Guide to EMIS Incentives***, LBNL, 2014: http://eis.lbl.gov/pubs/emis-incentives-guide.pdf. This guide presents a snapshot of programs; contact the program to find out about current offerings.

In some cases, funding assistance may be available to offset first costs of EMIS implementation. Funding assistance could come from green loan programs or grants within your organization, or from utilities or government grants, rebates or incentives.

Evidence that EMIS enable significant site energy savings can be found in case studies[13], and documented in EIS *Technology Costs, Benefits and Best Practice Uses*[14] and some benefits are also outlined in Table 4. In practice, capital improvements and other efficiency programs are often implemented in conjunction with EMIS-based analytics, making it difficult to isolate the savings attributable information technologies and data analytics. However, the results from Granderson et al. (2013)[15] *(and a growing body of single-case case studies)* indicate that in several dozen mostly enterprise or campus-level EIS deployments, site and portfolio savings of 17 and 18 percent, and utility cost savings of 0.4 dollar per square feet, respectively, *could not have been achieved without* the use of EIS analytics technologies. These “proof points” can be used to complement and supplement the organization-specific analyses**.** The business case must include key financial metrics, like the simple payback period and return on investments and should relate to the overall organizational goals. Granderson et al. (2013) [16] identified in three of four cases for which sufficient information was available, the payback of EIS implementation was less than two years.

Having considered aspects of cost/benefit analysis and refining the EMIS design to achieve the required financial metrics, indirect financial non-monetary benefits should also be part of the business case. For example, access to data to inform organization-specific custom analyses, (e.g., project-specific energy savings and payback; the ability track organizational energy goals; and the provision of better reporting mechanisms to diverse organizational stakeholders).

EMIS Implementation

This section provides an overview of specification and procurement, installation, commissioning, and training steps for an EMIS.

Specification and Procurement

After the intended scope and use of the EMIS is fully defined, a specification and request for proposals (RFP) can be developed and issued. The specification should include the requirements for (1) technology capability; (2) the IT, networking, and communications aspects of the technology; (3) technical warranty, support, and training; and (4) testing and commissioning. It is important to specify the capabilities of the EMIS, to facilitate an owner-driven procurement process, analogous to traditional building technologies.

A template RFP, specification, and selection guidance have been developed to provide requirements language for an energy information system, or related monitoring and diagnostic EMIS technology. By editing, adding to, and deleting from the template, potential EMIS adopters will produce a custom specification based on their organization's specific goals and energy management processes. Table 5 provides illustrative examples of specific items that are covered in the different categories of the template specification. The full set of procurement support materials can be accessed from DOE's Better Buildings Alliance EMIS Technology Solutions team website.[17]

TABLE 5: CATEGORIES AND SPECIFIC ITEMS FOR TECHNOLOGY SPECIFICATION

Categories	Specific Items
Technology capabilities	Functions and features to display and analyze building energy or system data, for example: • Energy performance analysis • Demand management • Greenhouse gas tracking • Integration with external data sources and building automation system • Reporting and data export
IT requirements	Data storage, backup, and hosting Security Permissions and access control Ease of usability Networking protocols
Technical warranty, maintenance support, and training	Ongoing technology support, updates, and user training
Testing and commissioning	Verification, testing, and documentation to be conducted after technology installation and configuration

One thing to caution is that the specification should not extensively mix capabilities across those typical for a given EMIS type. Doing so will result in a highly customized solution and therefore, high technology costs. For example, most interval data analysis technologies such as EIS will not provide extensive utility billing management capabilities, or control capabilities. Please refer to Table 1 for the distinguishing factors and core attributes of EMIS technologies. In addition, each section of the specification should distinguish between "required" capabilities and "preferred" capabilities, to help responding vendors identify high-priority technology needs.

The technology specification represents the starting point of the procurement process. Following completion of the specification, issue and release an RFP to obtain proposals from EMIS vendors. The specification should be included in the RFP as a main section or appendix, so that vendors can respond appropriately in their proposals.

In addition to a template RFP and specification, the supporting materials include guidance for proposal evaluation and selection. They provide an objective framework and point/scoring process to assess multiple competing proposals that satisfy the scope of work and other RFP requirements. The framework can be used to make a "first cut" and rule out some of the proposals, or to make a final selection entirely on the scoring results. For a balanced review, it is recommended that more than one evaluator participate in the scoring activity. Some selection considerations that extend beyond total costs are as follows:

- How do the proposed technology and services satisfy the required and preferred capabilities and functions defined in the specification?
- Does the proposed technology include capabilities that are considered "best practice" or "state of the art" relative to similar products?
- How well do any additional features or capabilities that were highlighted in the proposal meet the owner's current and future needs?
- Does the proposer have a good history of experience with portfolios or sites similar to yours?
- Does the proposer demonstrate strong experience with technology design, provisioning, installation, and commissioning?
- Are the protections and assurances for continuity of services, in the event of disruptions to the proposer's business-as-usual operations sufficiently addressed?

Installation

Once the EMIS product has been selected, the next step is to install the system. The vendor will handle most of the installation work. The organization needs to assign key points of contact to work with the vendor's installation crew, arranging for site access, network access as needed, etc. Key considerations to discuss with the vendor during installation are summarized below.

- Are there new meters installed? Can the meter data be transferred from the utility?
- Are any shutdowns necessary to add sub-meters?
- Are utility-grade meters necessary?
- Are any gateways or other middleware needed to migrate the proprietary protocols to open protocols?

- Are data loggers required?
- What are the access permissions? Who has access to which user interfaces and reports?
- Does the existing BAS provide data of a quality that is sufficient for analysis (in contrast to the level of accuracy and robustness needed for control)

To learn more about challenges for meter installation and possible solution, consider reading Chapter 6 in the *Data Center Metering and Resource Guide*[18]. In addition, energy meters require periodic maintenance. A thorough description of periodic maintenance requirements are recorded in the *Metering Best Practices Guide*[19].

Commissioning the EMIS

Commissioning is the systematic process for verifying and documenting that the EMIS is designed, installed, and tested, and is capable of being operated and maintained according to the requirements. Just as traditional building systems and equipment are commissioned to ensure optimal and intended performance, an EMIS should be commissioned. During commissioning, the EMIS goes through an intensive quality assurance process to verify that the EMIS will operate as the owner intended and that staff are prepared to operate it as needed.

Benefits of commissioning are as follows:

- System operates according to design intent
- Meters and sensors are calibrated and reliably reporting accurate data
- Communications and networking are fully functional and robust
- Key performance indicators and tracked metrics are correctly calculated
- Software is bug-free
- Key integration points are maintained and operational
- Weather feeds are accurately integrated
- Historic data can be exported in the desired formats
- The user interfaces and reports are configured as desired

The EMIS provider should be required to provide a commissioning report upon technology hand-off that documents the end-to-end testing and verification of the system. The commissioning process consists of the integrated application of a set of engineering techniques and procedures to check, inspect, and test every operational component of the project. Metering accuracy is a key aspect of commissioning and is described further in the following:

- **End-to-end metering system check:** Problems with meter installation, setup, programming, networking, or display configuration will be revealed by this check
- **Sum checking:** This is another way to verify metering, by comparing the sums of sub-meters against the any upstream meters that capture the sum-total

Post-installation experience is invaluable in providing guidance for future specification and development of new controls and system integration. Input from the commissioning process can also help develop guidelines for standardization, design construction, and commissioning, as well as anticipated impacts of potential future technology. Documenting the process of commissioning is important. Key considerations related to system commissioning include:

- Performing point-by-point verification of systems
- Verifying system sequences
- Checking trends in logs
- Testing alarms

Training

Deriving maximum benefit from EMIS technology, particularly when the technology is newly introduced to the organization, requires user training. Focus this training not only on key technology features, but also on how they connect back to key activities and goals that were framed earlier. Training may be conducted by the technology provider, internal EMIS project lead, or by a combination of the two.

In considering the training that will be most useful to your organization, it can be helpful to ask the following:

- What aspects of the EMIS do people need training on (reporting, visualization, analysis and data interpretation, etc.)?
- Who needs to be trained, and how are their different roles and responsibilities accommodated in training materials?
- Will there be an on-site system administrator who manages and maintains user access rights?
- How must training materials, sessions, and documents be archived and made available for future reference?
- What are the required qualifications of the trainer?
- What is the desired medium? For example, in-person training, video tutorials, user guides, on-call help services?
- Will it be useful to have an initial training session, followed by subsequent sessions after some period of initial use of the system?

Training may be conducted by the technology provider, internal EMIS project lead or by a combination of the two.

EMIS Ongoing Usage

As the EMIS is transitioned from installation to ongoing use as an operational tool, several aspects of scale-up and evolving overtime usage will come into play. This section reviews these aspects in further detail. Specifically, it discusses strategies for scaling EMIS, allocation of resources, management of cash flow, incentive and motivation, and standard operating procedures.

Scaling EMIS

This section discusses two ways of scaling EMIS: ramping up EMIS complexity and scaling up EMIS usage in a portfolio.

The complexity or sophistication of EMIS use and capabilities should be increased over time. This may evolve differently, depending on the initial levels of monitoring and analysis that are applied within the organization. In general, it is recommended to first start with monthly energy tracking and whole-building interval data analysis (based on data availability), then move into system-specific investigations. This approach recognizes that insight and skill will increase with experience, and that data acquisition and analysis resources may need to be expanded gradually, as budgets and time permit. For an organization that has never implemented an EMIS, beginning with the features that only require existing data, or data that can be obtained with little additional cost and effort, is a good strategy. This allows savings to be obtained before gaining approvals for further investment.

Monthly utility bill analysis is a good starting point to begin an organization's energy conservation dialog, which can help identify how a building's energy performance ranks relative to its peers and help develop a habit of routine energy tracking. Significant efficiency gains can be achieved through the use of whole-building-level interval meter analysis and modest submetering.[20] Whole-building interval data enables users to understand how much energy is consumed at different times of the day and to identify efficiency opportunities relating to the scheduling and control of major building systems. Longitudinal benchmarking, load profiling, peak-load analysis, and energy anomaly detection are very useful for gaining insight into whole-building aspects of operation. Measurement and verification can be applied to quantify the resulting energy reductions. Once an organization has gained a solid understanding of whole-building behaviors and picked "low hanging fruit" it can incorporate more sophisticated analysis (equipment level FDD, etc.) into a continuous energy management approach and pursue further savings.

It is important to emphasize is that the EMIS market is rapidly developing as building information technologies advance. For example, the industry is seeing increasing levels of data integration between building automation systems and analytics platforms that do not offer control; this is enabling enhanced capabilities and increased use of system-level fault detection and diagnostics in combination with whole-building energy analysis. Therefore, what is true of today's market and today's technologies may be less applicable in the future, and it is important to continuously stay apprised of how EMIS technologies are evolving.

Beginning small, with a pilot, is highly recommended for EMIS implementation. The pilot provides an opportunity to prove the usefulness of the EMIS, test the system's ability to satisfy organizational needs, and refine system uses and requirements. Once the efficiency is demonstrated, the pilot can be expanded to other sites in the campus or portfolio with greater confidence and user experience.

Standardization is an important element in achieving successful scale-up. For example, the same data may be planned for collection across all sites in a portfolio, and using a standard data format can streamline the process of establishing associated metrics, trend analysis, and performance comparison between sites. Standard naming conventions for loads, meters and BAS trend logs can simplify data integration and point mapping activities and analysis between buildings or sites. As highlighted in the EMIS Procurement Support Materials resource[21], it is recommended to define your standardization requirements in RFP and statement of work documents.

Allocation of Resources

Remember, EMIS are human-in-the-loop technologies that require regular use to derive insights for improved efficiency, so allocation of appropriate resources is critical. Dedicating sufficient resources is a critical component of maximizing the value of the EMIS. Allocate sufficient labor hours to regularly review the EMIS analysis and reporting, detect anomalies, take follow-up actions to fix the problems identified, and communicate the results to organization leadership and employees. In addition, the meter/sensor system requires periodic maintenance such as calibration to ensure data accuracy. The extent to which work is performed by in-house engineering team or by outside service providers is dependent on the organization. If the organization has the people or time to manage the EMIS, all the work can be dispatched in house. If not, the organization can hire a trusted “analysis-as-service” consulting engineering firm (possibly the EMIS vendor) for day-to-day monitoring, analysis, and measure identification and prioritization. In that case, the internal operations and energy management team would take actions based on the service provider’s findings.

Organizational Resource Allocation Example

Description:

The Tower Companies, a real estate firm, has engaged consultative service AtSite to implement a real-time energy management program in three office buildings in Washington, D.C. in 2012. The interval whole-building utility electricity use, chiller electricity use, and whole-building natural gas use were continuously monitored and analyzed by AtSite’s experts with a web-based EMIS tool. Compared with 2012, electricity use decreased by 13 percent across all three buildings in 2013. The reduction in electricity expenses averaged $72,901 per building in one year. The key services provided by the third-party service firm included:

- Delivering a daily report to each building engineer and the Tower management team for quick energy pattern viewing
- Reviewing each building’s energy performance each day and contacting building engineers when anomalies were detected
- Holding a monthly meeting with the Tower management team and building engineers to review findings, offer actionable recommendations, and check the progress of ongoing energy conservation measures
- Providing charts, graphs, and metrics that reflect building energy performance for further investigation

To see the full Tower Companies story, visit http://www.nrdc.org/business/casestudies/files/tower-companies-case-study.pdf.

Managing Cash Flow

The improvement opportunities that are revealed through EMIS use can range from no-cost and low-cost measures to those that are more capitally intensive. Particularly in the case of enterprises and campuses, a common question is: where to begin in prioritizing facilities and measures for performance improvement efforts? To manage staff resources and cash flow, many organizations have found success in the following strategies:

- “Triage” a portfolio by identifying, and focusing more intensive analysis efforts on those sites with the highest EUI
- Implement no- and low-cost measures before moving on to and upgrading activities that require more capital investment
- Identify project “bundles” of like-measures that can be deployed across many sites in a single effort, thereby leveraging economies of scale
- Use the EMIS metering and analysis capabilities to document and quantify the utility cost savings that are achieved; use these successes to justify future efforts
- Use the EMIS utility bill analysis capabilities to process, audit or automatically process and pay utility bills. This speeds up data entry time and reduces errors. Reduced errors (such as missed bills or duplicate bills) eliminate extra processing time
- In sites that offer modern controls automation, and in territories where programs are available, consider participation in demand response programs as a means of generating additional savings
- For campuses or portions of portfolios with a large utility footprint, contact efficiency program managers to identify potential incentives to offset EMIS first costs, as well as rebates and other performance incentives

Organizational Cash Flow Management Example

Description:

Starting from July 2012, the City of Beaverton, Oregon, participated in a pilot program provided by Energy Trust of Oregon. It implemented a real-time energy information system at two city facilities: the city library and city hall. The program provided a unique blend of 15-minute-interval energy monitoring, an expert consultant from Air Advice, and low- to no-cost recommendations for energy savings.

The city hall and library were selected because the analysis showed these sites to be the most energy intensive of all the candidate buildings based on square footage, age and energy savings potential. With EIS findings, the city first implemented no-cost energy conservation measures (ECMs) that could be deployed internally. Then the city pursued low-cost ECMs with the highest return investment that were already budgeted for the fiscal year. The following low- to no-cost ECMs were implemented by Beaverton in the two buildings:

- Reduced lighting hours and HVAC run-time hours to better reflect actual building occupancy and service needs
- Calibrated temperature control sensors
- Calibrated carbon dioxide sensors for more effective control of the demand controlled ventilation system
- Repaired outside air dampers to make maximum use of free cooling
- Tested all variable air volume (VAV) box dampers to allow satisfaction of the minimum airflow requirement

In the year ending July 2014, the corresponding whole-building energy savings were 23% at the library and 15% at the city hall compared to the baseline year (2011), resulting in over $35,000 annual energy savings in these two facilities. Based on these successes, the city is also considering an expansion of real-time monitoring to other facilities.

To see the full Beaverton, Oregon, story, visit http://betterbuildingssolutioncenter.energy.gov/implementation-models/real-time-energy-monitoring.

Incentives and Motivation

Incentives are critical to keep staff motivated and meet performance targets. There are a variety of ways to motivate staff, including bonuses. Some examples include the following:

- Create company-wide recognition for staff and occupant efforts to save energy based on performance targets established within the EMIS
- Give occupants access to the dashboards and introduce efforts to improve efficiency
- Release a monthly scorecard and engage occupants in building performance tracking
- Establish accountability: Create a flow of information about building performance up and down the chain of command; where appropriate include efficiency-related goals and expectations into position descriptions and performance review processes. Well-defined reporting procedures help ensure accountability and drive action
- Establish a training program: By running a training program you can increase awareness of the benefits of using the EMIS and understanding of features and capabilities to support and streamline job activities
- Make performance visible: Use the EMIS to generate visibility into energy performance relative to specific organizational goals. Share reports that reflect progress toward the goals and objectives and reflect the impact the EMIS is having through these reports
- Involve organizational and employee development or human resources as a strategic partner, and make the energy management program transparent and available to all employees
- Make a public pledge to improve the energy intensity of your portfolio, delivered by a senior executive, illustrating organizational priorities and backing

Establish a Process for Managing and Responding to EMIS Findings

Ownership and integration of the EMIS into standard business practices is important, and a defined workflow is essential for planning how insights will be acted upon. In addition, the EMIS itself must be maintained; in most cases, the vendor will offer system maintenance and data quality assurance services either in bundled or optional offerings.

Once the efficiency opportunities have been identified by the EMIS, either by in-house staff or service providers, there needs to be a standard set of processes defined for taking action that will generate savings. Facility staff need to identify who is going to respond to each finding, what permissions or authorizations are needed, which departments or business units need to be involved, relevant work order request systems, and the relative priority level of actions that have been identified. Sometimes actions such as equipment scheduling can be addressed by site-level operational staff. In other cases, further investigation may be required to determine the specific root inefficiencies. Having a “standard operating procedure” in place will save time, and maximize the likelihood that fixes will be implemented.

Prioritizing the findings is important. The downside to take the findings on a first come first served basis is that engineers or technicians are possibly working on lower priority incidents while higher priority findings, which could be costing money, are not being addressed. A useful way to prioritize actions is to establish thresholds for energy/cost impacts that have a bearing on how quickly the problems must be addressed once they are detected. Many automated fault detection and diagnostics tools will provide prioritization, however it is necessary to determine a comprehensive approach to organizational response, that may span the insights gained from the use of multiple technologies. Table 6 provides an example from a FDD tool.

TABLE 6: ILLUSTRATIVE EXAMPLE OF FAULT PRIORITIZATION FROM AN AUTOMATED FDD TOOL[22]

Building	Bldg. Cluster	Equipment	Fault and Diagnosis	Priority	Estimated Savings
Building 58	Cluster E	AHU – 012	Leaking chilled water valve	High	$11,291
Building 58	Cluster E	AHU – 003	Damper position fault	High	$4,782
Building 53	Cluster E	VAV – 022	Over cooling	High	$2,235
Building 58	Cluster E	CHI – 002	Changes to set points	Medium	$895
Building 54	Cluster E	VAV – 006	Air temperature sensor failure	Low	—

Functional or energy performance problems will be identified during the regular EIS evaluations. It is good to log the issues discovered and those that have been resolved. An “energy champion” could be assigned whose responsibility is to start each day with the review of the energy use of key components and formulates an energy plan for the days to come. Using the EMIS you can view the out-of-range uses. For examples, at the National Renewable Energy Laboratory (NREL), energy use is viewed daily for out-of-range end uses. In the first year of operations, evening lighting energy use was out of range, because the custodial staff was not accounted for in the model. To address the issue, they took two actions: First, the energy model that was created based on as-built conditions was calibrated slightly to account for the realistic use. Second, they apprised custodial staff in periodic trainings of the locations of switches with shorter timeouts (lights automatically turn off after ten minutes for “walk-through” switches versus two hours for regular switches). Staff were requested to turn on switches only for zones that they were actively cleaning or moving through as opposed to all office lights.

Appendix A: Metering Technologies[23]

TABLE A-1: WHOLE-BUILDING ELECTRIC METERING TECHNOLOGIES

Meter Technology	Level	Description
Mechanical/electro-mechanical	Basic building	Energy use is read manually using a mechanical dial on the meter, and monthly energy consumption is calculated by comparing the dial position between previous and current readings.
Advanced (solid state/digital) meters	Advanced building	Advanced meters require no moving parts, but rely instead on integrated circuits, built-in memory, and communication technology.

TABLE A-2: ELECTRIC SYSTEM OR SUBSYSTEM METERING

Meter Technology	Use	Description
Power Meter (PM)	Energy consumption from a single point of use	Can be used to provide peak demand to identify when highest usage occurs. Applications include: tenant submetering, measuring output from solar panels, and monitoring plug load power draw. Most power meters can provide the following information: power, energy, power factor, volts, amps, and kVAR.
Multi-Circuit Power Meter (MCM)	Energy consumption of up to eight circuits within one panel board	MCMs are typically used to monitor the energy consumption from a group of associated loads. A MCM typically provides limited information about a specific monitoring point: power, energy, and amps. A MCM can monitor multiple circuits fed by the same voltage source; typical installations include apartment complexes or office buildings.
Branch Circuit Power Meter (BCPM)	Energy consumption of all the circuits within one panel board	A BCPM is a robust metering option that can provide data for all of the connected loads within one panel board. BCPMs are typically used when the power consumption of unassociated loads within one panel board (i.e., HVAC and lighting) is wanted and are used where maximum metering flexibility is desired. The information provided by a BCPM typically mirrors an MCM (power, energy, amps).

TABLE A-3: WHOLE-BUILDING NATURAL GAS METERING TECHNOLOGIES

Meter Technology	Type	Description
Diaphragm	Positive displacement	The most common type of gas meter; commonly found on buildings with line sizes of 0.75 to 2 inches. Within the meter body there are two or more chambers formed by movable diaphragms. The diaphragm movement is converted into flow measurement.
Rotary	Positive displacement	Typically found on buildings with line sizes of 1.5 to 4 inches and located on buildings with higher gas flow rates. The fluid physically displaces the measuring mechanism to increment a recording dial.

TABLE A-4: NATURAL GAS SYSTEM AND SUBSYSTEM METERING TECHNOLOGIES

Meter Technology	Type	Description
Orifice	Differential pressure	Relies on the velocity-pressure relationship of flowing fluids. The orifice element is held between two flanges in the fluid stream. As fluid flows through opening in the orifice plate, the restriction creates a pressure differential proportional to the flow rate.
Turbine	Velocity	As the fluid passes, an impeller rotates at a speed directly proportional to the velocity, and hence, the flow rate. These typically have better turndown ratios than other meter types.
Ultrasonic	Ultrasonic	Measures the speed of gas movement by measuring the speed at which sound travels in the gaseous medium within the pipe. The meter creates a “ping” with a transducer and measures the time elapsed before the sensor receives the sonic pulse.

Resources

The following resources can be used to learn more about EMIS technologies and issues related to their use:

A Specifications Guide for Performance Monitoring Systems, Kenneth L. Gillespie et al., Lawrence Berkeley National Laboratory, 2007, available at: https://old.northcarolina.edu/info/vendors/Performance_Monitoring_Spec_Guide_Version_1_2007-03-23.pdf.

Advanced Metering and Energy Information Systems, New Building Institute (NBI), 2009, available at: http://newbuildings.org/advanced-metering-and-energy-information-systems.

Building Energy Information Systems: State of the Technology and User Case Studies, Jessica Granderson et al., Lawrence Berkeley National Laboratory, November 2009, LBNL-2899E, available at: http://eis.lbl.gov/pubs/beis-case-studies.pdf.

Data Center Metering and Resource Guide (version 1.1), Rod Mahdavi and Steve Greenberg, Lawrence Berkeley National Laboratory, 2015, available at: https://datacenters.lbl.gov/resources/data-center-metering-and-resource-guide.

Energy Information Handbook: Applications for Energy Efficiency Building Operations, Jessica Granderson et al., Lawrence Berkeley National Laboratory, 2011, available at: http://eis.lbl.gov/downloads/energy-information-handbook.pdf.

Energy Information Systems: Technology Costs, Benefits, and Best Practice Uses, Jessica Granderson et al., Lawrence Berkeley National Laboratory, 2013, available at: http://eis.lbl.gov/pubs/lbnl-6476e.pdf.

Energy Management and Information Systems (EMIS) Technology Classification Framework, Jessica Granderson, Lawrence Berkeley National Laboratory, 2013, available at: http://eis.lbl.gov/pubs/emis-tech-class-framework.pdf.

Energy Management Systems for Food Service Application, Navigant Consulting, Inc. and Donna Trovalli, 2014, available at: http://www4.eere.energy.gov/alliance/sites/default/files/uploaded-files/ems-guidance-for-food-service-applications.pdf.

EMIS Crash Course, Jessica Granderson et al., Lawrence Berkeley National Laboratory, 2013, available at: http://eis.lbl.gov/pubs/emis-crash-course.pdf.

Energy-smart buildings: Demonstrating how information technology can cut energy use and costs of real estate portfolios. Accenture. 2011, available at: http://download.microsoft.com/download/4/8/8/4885BBB9-2675-42CB-9CF2-F11B69C3C2FB/energy-smart-buildings-whitepaper-1.pdf

Metering Best Practices: A Guide to Achieving Utility Resource Efficiency, Federal Energy Management Program, U.S. Department of Energy, 2011, available at: http://energy.gov/sites/prod/files/2015/04/f21/mbpg2015.pdf

Monitoring & Reporting Applications Guide, Energy Trust of Oregon, 2011, available at: http://energytrust.org/library/forms/NBE_MR_Applications_Guide_v01.pdf.

Real-time Energy Management, A Case Study of Three Large Commercial Buildings in Washington, D.C., Philip Henderson and Meg Waltner, Natural Resource Defense Council, 2013, available at: http://www.nrdc.org/business/casestudies/files/tower-companies-case-study.pdf

Regional Guide to EMIS Incentives, Lawrence Berkeley National Laboratory, 2014, available at: http://eis.lbl.gov/pubs/emis-incentives-guide.pdf.

Realizing High-Performance Buildings, National Renewable Energy Laboratory (NREL), 2015, available at: http://www.nrel.gov/docs/fy15osti/62530.pdf.

Submetering of Building Energy and Water Usage, National Science and Technology Council Committee on Technology, 2011, available at: http://www.bfrl.nist.gov/buildingtechnology/documents/SubmeteringEnergyWaterUsageOct2011.pdf.

Synthesis of EMIS Resources, Lawrence Berkeley National Laboratory, 2014, available at: http://eis.lbl.gov/pubs/synthesis-emis-resources.pdf

The Building Performance Tracking Handbook: Continuous Improvement for Every Building, California Commissioning Collaborative, 2011, available at: http://www.cacx.org/PIER/handbook.html.

Endnotes

1 *Energy Information Systems: Technology Costs, Benefits, and Best Practice Uses*, Jessica Granderson et al., Lawrence Berkeley National Laboratory, 2013. Available at: http://eis.lbl.gov/pubs/lbnl-6476e.pdf.

Building Energy Information Systems: State of the Technology and User Case Studies, Jessica Granderson et al., Lawrence Berkeley National Laboratory. 2009. Available at: http://eis.lbl.gov/pubs/lbnl-2899e.pdf.

Case Studies of Energy Information Systems and Related Technology: Operational Practices, Costs, and Benefits. Naoya Motegi et al., Lawrence Berkeley National Laboratory. 2003. Available at: http://eetd.lbl.gov/node/52157.

2 Adapted from The Building Performance Tracking Handbook, California Commissioning Collaborative. 2011. Available at: http://www.cacx.org/PIER/handbook.html.

3 *Portfolio Manager DataTrends Series*. EPA, 2012, Available at: http://www.energystar.gov/sites/default/files/buildings/tools/DataTrends_Savings_20121002.pdf.

4 *Enhanced Automation: Technical Options Guidebook*. California Energy Commission, Available at: http://www.energy.ca.gov/reports/2002-05-15_400-02-005F.PDF

5 Energy Impact of Commercial Building Controls and Performance Diagnostics. TIAX LLC, 2005, Available at: http://s3.amazonaws.com/zanran_storage/www.tiaxllc.com/ContentPages/42428345.pdf.

6 For more details about each way, consider reading STEP 3 in *ENERGY STAR Guidelines for Energy Management*. Available at http://www.energystar.gov/buildings/tools-and-resources/energy-star-guidelines-energy-management.

7 *Realizing High-Performance Buildings*, National Renewable Energy Laboratory, 2015. Available at: http://www.nrel.gov/docs/fy15osti/62530.pdf.

8 *Hitting the Whole Target: Setting and Achieving Goals for Deep Efficiency Buildings.* Karl Brown et at., 2010. Available at www.aceee.org/files/proceedings/2010/start.htm.

9 *Realizing High-Performance Buildings*, National Renewable Energy Laboratory, 2015. Available at: http://www.nrel.gov/docs/fy15osti/62530.pdf.

10 Please see *ENERGY STAR® Portfolio Manager Data Collection Worksheet* for detailed data requirements. Available at: http://www.energystar.gov/ia/business/downloads/PM_Data_Collection_Worksheet.doc.

11 *Metering Best Practices: A Guide to Achieving Utility Resource Efficiency,* Federal Energy Management Program, U.S. Department of Energy, 2011. Available at: http://energy.gov/sites/prod/files/2015/04/f21/mbpg2015.pdf

Advanced Metering and Energy Information Systems, New Building Institute, 2009. Available at: http://newbuildings.org/advanced-metering-and-energy-information-systems.

Submetering of Building Energy and Water Usage, National Science and Technology Council Committee on Technology, 2011, Available at: http://www.bfrl.nist.gov/buildingtechnology/documents/SubmeteringEnergyWaterUsageOct2011.pdf.

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Energy-Smart Buildings: Demonstrating How Information Technology Can Cut Energy Use and Costs of Real Estate Portfolios. Accenture, 2011, available at: http://download.microsoft.com/download/4/8/8/4885BBB9-2675-42CB-9CF2-F11B69C3C2FB/energy-smart-buildings-whitepaper-1.pdf

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15 *EMIS Specification and Procurement Support Materials,* Better Building, U.S. Department of Energy, 2015. Available at: https://www4.eere.energy.gov/alliance/sites/default/files/uploaded-files/emis_proc_spec_BBA_FINAL_021815_508.pdf, Accessed on August 13, 2015.

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[19] *Metering Best Practices: A Guide to Achieving Utility Resource Efficiency*, Federal Energy Management Program, U.S. Department of Energy, 2011, available at: http://energy.gov/sites/prod/files/2015/04/f21/mbpg2015.pdf

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[21] *EMIS Specification and Procurement Support Materials*, Better Building, U.S. Department of Energy, 2015. Available at: https://www4.eere.energy.gov/alliance/sites/default/files/uploaded-files/emis_proc_spec_BBA_FINAL_021815_508.pdf.

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