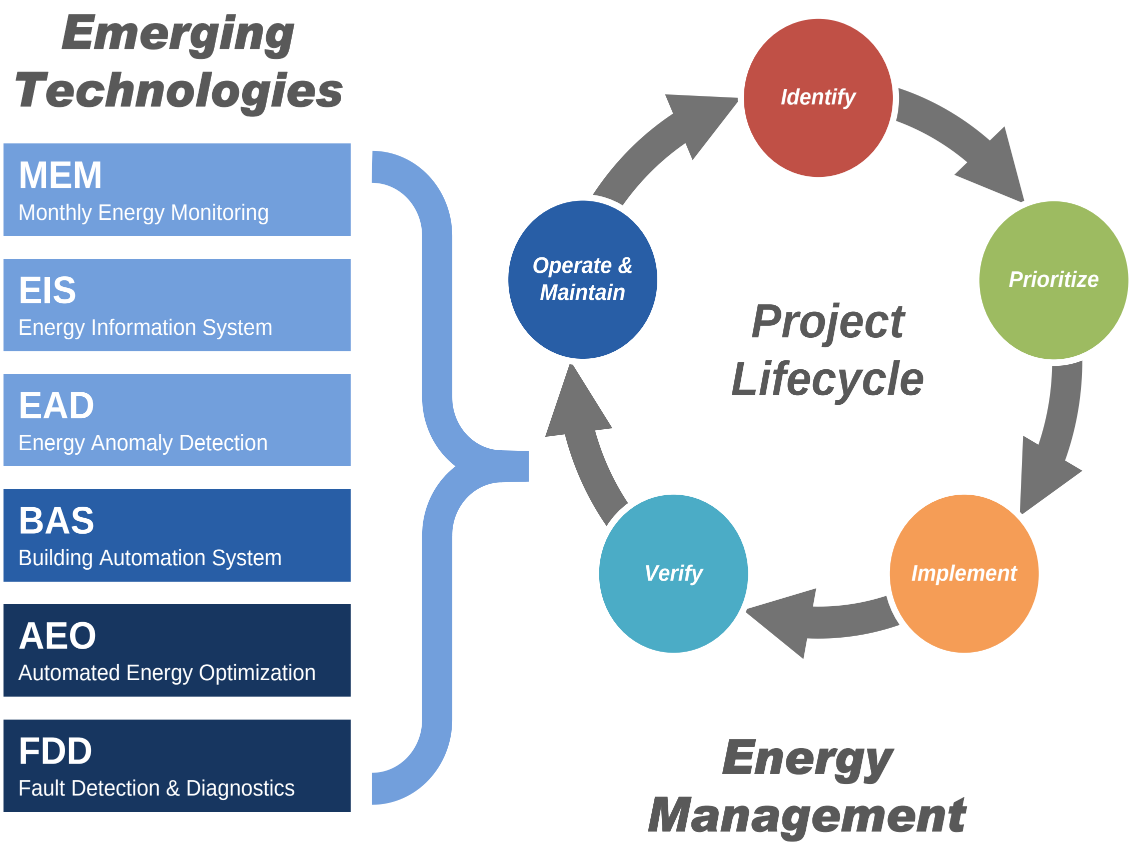
Energy Management & Information Systems

ET Project Number: ET11PGE1141



Project Manager: **Mark Haberman**
Pacific Gas and Electric Company

Prepared By: **Jeff Guild, Eric Koeppel, & Curtis Hilger**
Enovity, Inc.
100 Montgomery St., Ste. 600
San Francisco, CA 94104

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Pacific Gas and Electric Company®

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Abbreviations and Acronyms

ADR	Automated Demand Response
AEO	Automated Energy Optimization
BAS	Building Automation System
DDC	Direct Digital Control
EAD	Energy Anomaly Detection
EEM	Energy Efficiency Measure
EIS	Energy Information System
EMIS	Energy Management and Information System
FDD	Fault Detection and Diagnostics
IPMVP	International Performance Measurement and Verification Protocol
LAN	Local Area Network
LEED	Leadership in Energy and Environmental Design
MEM	Monthly Energy Monitoring
NIST	National Institute of Standards and Technology
RCx	Retro-Commissioning
RTP	Real-time Pricing
SaaS	Software as a Service
WAN	Wide Area Network

FIGURES

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EXECUTIVE SUMMARY

PROJECT GOAL

This study evaluates the potential for of energy management information systems [EMIS] to create or enhance energy savings and the effectiveness of various technologies that enable successful EMIS integration in existing commercial buildings.

PROJECT DESCRIPTION

EMIS is an expansive and evolving product category. To provide a cohesive and useful assessment of the technologies involved and provide focus where it is due, this study provides insight on the current landscape of EMIS products, their potential opportunity for achieving energy efficiency, and suggests targeted areas for further field study..

This study focuses on providing an overview of Commercial Building EMIS solutions. Areas of exploration include product attributes/features/classifications, technology encumbrances and market barriers to adoption, and the potential of EMIS to effect or enhance energy efficiency. With the EMIS overview as context, this study provides hypotheses about the energy savings potential of such products and recommendations for EMIS deployment and testing in PG&E territory.

Suggested further studies include testing and reporting on the outcome of EMIS deployment. Various sections of this report serve as placeholders for content and results for further study.

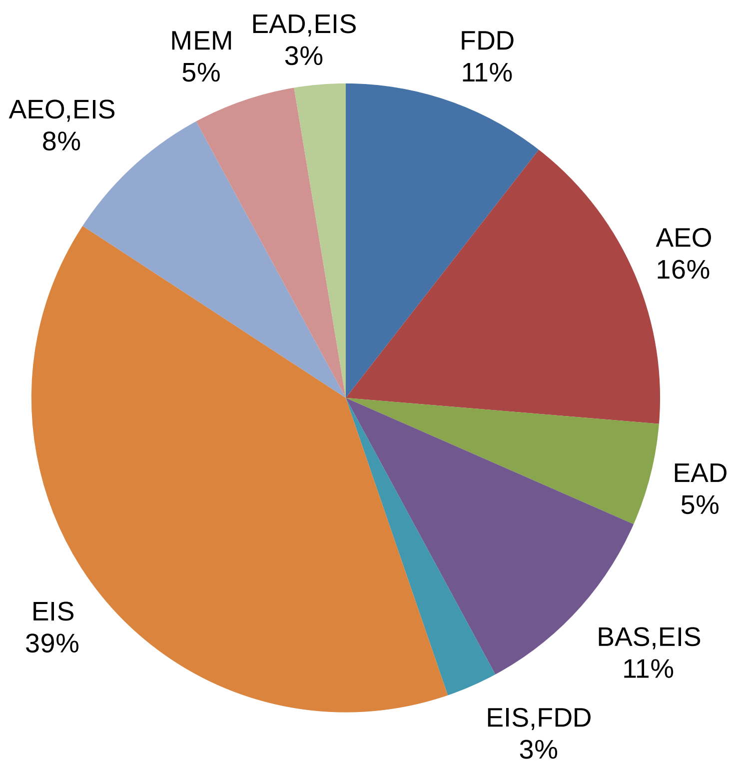
PROJECT FINDINGS/RESULTS

Review of a sample population of commercially available EMIS products to identify key technologies, system attributes, and technical capabilities provides a framework and basis to compare and contrast various EMIS in the market. The depth of this study is limited by the extent to which product information is available in public domain. The breadth and rapidly emerging and evolving nature of the EMIS products also provides a challenge for customers (and industry experts) to stay current with current product offerings due to frequent product rebranding, frequent product/company acquisitions, and continuously evolving value propositions that are as vague as they are dynamic. This last point not only presents a major barrier to customers for greater EMIS adoption, but also makes it difficult to identify exactly what capabilities the tools offer, what infrastructure requirements are needed for deployment, and what factors differentiate each solution.

To begin to consider such diverse and evolving product offerings, a framework to classify EMIS, presented in the Background section, establishes six EMIS product classifications (Consortium for Energy Efficiency, Inc. June 2011) that are differentiated by key features/attributes:

- Monthly Energy Modeling (MEM) systems
- Energy Information Systems (EIS)
- Energy Anomaly Detection (EAD) systems
- Building Automation Systems (BAS)
- Advanced Energy Optimization (AEO) systems
- Fault Detection and Diagnostic (FDD) systems

FIGURE 1 EMIS PRODUCT CLASSIFICATION SUMMARY



Each EMIS product, differentiated using key product requirements and attributes such as data scope and interval; infrastructure requirements; architecture and deployment configurations; and technical features, falls into one or more of the six product classifications (see Figure 1). Of the thirty-eight products evaluated, an overwhelming majority of solutions fall into the energy information systems (EIS) classification.

A review of common customer attributes, distilled from a PG&E focus group on EMIS, presents customer specific encumbrances and drivers to broad EMIS adoption. Focus group participants representing small to medium size business [SMB] customers with a basic awareness of energy efficiency share common barriers to EMIS adoption. Experiencing difficulties similar to those faced during the product review portion of this research, the majority of these SMB customers do not fully understand, appreciate, or believe the value proposition of the products. Larger customers, though typically more sophisticated in energy management, also shared a dubious outlook on the product class.

To evaluate and identify specific areas where each of the specific EMIS classifications can assist a customer with achieving their energy efficiency goals, the Energy Project Lifecycle process, presented in the Emerging Technology/Product section, offers a breakdown of five distinct phases of an energy project where an EMIS can enhance or create energy management opportunities. Different EMIS solutions can offer strengths at different points of the life cycle and in different ways. A top-down analysis approach utilizes easily accessible macro-level data (e.g. whole building energy use, weather, time of day, occupancy) and typically helps identify general energy savings opportunities such as demand reduction in major end-use categories with a general idea of the energy savings magnitude. From the other end of the spectrum, a bottom up synthesis approach utilizes local micro-level data (typically data from a BAS) to identify specific system or equipment faults that adversely affect energy use. While most products currently fall into the extreme ends of the spectrum between top-down and bottom-up, customers having to make a choice between the two is fast becoming a false dilemma as these products begin to converge complementary features and ranging appeal to different audiences within the same customer.

PROJECT RECOMMENDATIONS

The following proposed energy efficiency pilot projects, detailed in the Recommended Pilot Projects section will test the effectiveness of enabling technologies that enhance or facilitate EMIS application and implementation at different points of the energy project lifecycle and across different customer/market segments:

1. Utilize EMIS to promote continuous automated customer demand control (distinct from demand response) through local (BAS) in response to real-time customer-specific energy use and pricing
2. Promote the correction of detected faults identified via Fault Diagnostic Detection (FDD) system by pairing with it an Energy Anomaly Detection (EAD) system in order to associate operational faults with an energy anomalies
3. Target SMBs with express, low cost EIS and EAD EMIS solutions by using existing utility meter interval data

INTRODUCTION

A review of the commercial building EMIS market landscape shows the emergence of key drivers that are shaping the way the commercial building industry is approaching the balance between achieving energy efficiency goals and maintaining tenant comfort with traditional building systems. The role and energy efficiency potential for building management systems has changed with the wide-spread adoption of direct digital control (DDC), the ubiquity of computer-based networks, and low-costs of increasingly sophisticated integrated circuits, and network/communication connectivity.

PRODUCT TRENDS

ENERGY DASHBOARDS FOR LEED

EMIS systems are predominantly marketed as energy dashboards to help a building gain LEED points. Due to the public facing aspect of these applications, graphics and information design is a top priority. Both aesthetic appeal and ease of understanding for basic users are highly important criteria.

SOFTWARE AS A SERVICE

EMIS products using the Software as a Service (SaaS) model are gaining traction. These cloud-based systems advertise reduced IT costs and simplified integration, which are key drivers for reducing operational costs and providing turn-key energy solutions. The SaaS model is a drastic change from existing software-based energy management and building automation products; therefore it is typically used by new entrants into the marketplace who are part of a growing energy conscious market segment.

ETHERNET AND INTERNET CONNECTIVITY: A HARD REQUIREMENT

Most systems require Ethernet connectivity at the WAN/LAN level. Internet connectivity is emerging as both a hard requirement and a means to provide additional data for AEO systems such as local weather data.

OPEN PROTOCOLS PROMOTE INTEROPERABILITY

Building automation system networking protocols (e.g. BACnet, Lon) and internet-based protocols are common connectivity requirements that aim to promote interoperability between existing building equipment and EMIS products.

FAULT DETECTION AND DIAGNOSTICS

The introduction of FDD solutions to the marketplace has trailed other other categories of EMIS. Four FDD solutions represent only 11% of the product sample in this study; two of which are relatively new market entrants. This is likely due to FDDs historical dependency on a broad scope of in-building data, which can be difficult to obtain. FDD also typically targets a narrower consumer/audience with a direct interest in general building operation..

BACKGROUND

An Energy Management and Information System (EMIS) is a tool, system, or service that provides information about energy use or manages energy consumption. There are several types of EMIS used in commercial applications. An overview of system attributes and common architectures are discussed. A general classification of common EMIS types is presented for further discussion.

CLASSIFICATIONS

EMIS product classifications have been developed by using a combination of literature review and the product research. For each classification, a list of defining attributes has been provided. A summary and listing the distinguishing characteristics of each classification is shown in Table 1.Note that these product classifications are not mutually exclusive, i.e. an EMIS product can fall into more than one category.

TABLE 1 EMIS CLASSIFICATION SUMMARY

Classification	Abreviation	Data Scope	Data Interval	Features
Monthly Energy Monitoring System	MEM	Whole Building Energy, Cost	Monthly	Energy Normalization
Energy Information System	EIS	Whole Building Energy	Hourly, 15-minute, Real-time	Energy Normalization, Reporting
Energy Anomaly Detection System	EAD	Whole Building Energy	Hourly, 15-minute, Real-time	Advanced Energy Modeling, Anomaly Detection, Energy Normalization
Building Automation System	BAS	Control Parameters	Hourly, 15-minute, Real-time	Direct System Control
Automated Energy Optimization System	AEO	Whole Building Energy, System Level Energy, System Performance	Hourly, 15-minute, Real-time	Direct System Control, Parameter Optimization
Fault Detection and Diagnostics System	FDD	System Performance, Control Parameters	Hourly, 15-minute	Fault Detection

MONTHLY ENERGY MONITORING

Monthly Energy Monitoring (MEM) systems analyze energy bill data. They use a top-down approach that aims to help with utility bill reconciliation, multi-building use comparison and period-to-period comparisons.

ENERGY INFORMATION SYSTEM

Energy Information Systems (EIS) provide a comparison of energy consumption and energy demand between separate time periods. Data scope may be down to the system data interval, within a single facility or across multiple similar facilities.

ENERGY ANOMALY DETECTION

In addition to EIS applications, an Energy Anomaly Detection (EAD) system identifies when a building or system is operating outside of the expected performance. It is also able to identify and prioritize energy efficiency and demand response opportunities by modeling impacts of potential changes.

BUILDING AUTOMATION SYSTEM

Building Automation Systems (BAS) control the operation of equipment in order to optimize building comfort through parameters such as set points and schedules. A BAS is possibly the most familiar type of EMIS to building operators and controls contractors.

AUTOMATED ENERGY OPTIMIZATION

Automated Energy Optimization (AEO) systems control the efficient operation of equipment based on schedules, temperature set points and automated feedback loops.

FAULT DETECTION AND DIAGNOSTICS

Fault Detection and Diagnostics (FDD) systems identify, notify and recommend solutions when a system or component is operating outside of expected performance criteria. They also provide continuous auditing of monitored systems and persists fault events to assist with operational improvements.

EMIS SYSTEM ATTRIBUTES

DATA SCOPE

Data scope refers to the type and quality of data that an EMIS uses in order to carry out its operations and responsibilities. There are five types of data scope.

WEATHER

Weather data is commonly used to normalize measured energy use as a means of predicting future energy use. Typical weather data measurements include:

- Outside Air Temperature

- Wet Bulb Temperature
- Relative Humidity
- Wind Speed and Direction
- Solar Radiation

Weather data is obtained through two mechanisms. It can be measured at a facility or it can be accessed remotely via one or more reputable weather data services. Local measurement is a more suitable approach where higher sampling intervals (> 15 min) or near real-time data is required.

WHOLE BUILDING ENERGY

Whole building energy is measured using the facility's energy meters. Energy meters may either be those provided by the utility from which a facility receives its energy or are dedicated meters that have been installed to measure energy use for a building that is on a shared utility meter. Whole building energy meters are typically used to measure consumption of the following utilities:

- Electricity (kW, kWh)
- Natural Gas (therms)
- Chilled Water (ton-hr)
- Heating Hot Water (Btu)
- Steam (pounds)
- Water (gpm)

SYSTEM LEVEL ENERGY

Energy that is measured at a system boundary provides disaggregated energy information for a facility. One or a combination of meters are be used depending on the diversity of fuel types being measured. System boundaries can encapsulate a single piece of equipment or can include several pieces of equipment. System level measurements account for energy use at a higher level of detail than whole building measurements; however, the increased level of detail requires additional energy meters for each system being measured.

COST

Energy cost, typically obtained from a utility bill, provides accounting detail in order to track operating costs associated with energy consumption. Given the unit cost of energy, an EMIS can provide additional detail regarding the energy cost of a whole building or for a given system.

Control Parameters

Control Parameters typically represent operating parameters within a building or facility such as such as the temperature set point on a thermostat. Control parameters can be either static or change over time. A control system will have multiple parameters that determine how the system behaves. In the thermostat example, an EMIS may use the current room temperature and compare it to the control parameter (i.e. thermostat set point) of the temperature control system for the room to indicate if the correct room temperature is being satisfied. Control parameters are a key component for determining if a control system is operating properly.

System Performance

System performance is the most subjective data scope and depends largely on the EMIS that defines it. Assessment of system performance can include one or more measured values that are used to determine if a system is performing as intended. A measure of system performance, when compared to the desired performance, is used to quantify the gap between actual and optimal conditions.

Data Interval

Depending on the needs of the EMIS, input data may be required at specific or minimum intervals. For EMISs that provide near instantaneous reporting or control, near real-time input data is required. For systems that utilize external data -- data that is collected and stored by a separate system or third-party -- the latency of the remote system and its means of data delivery will limit how responsive the EMIS will be able to provide feedback to other systems or users. For example, PG&E's InterAct system is capable of delivering 15-minute interval data of a customers energy use; however data is currently only available for the previous day.

Typical data intervals include:

- Monthly
- Hourly
- 15 Minute
- Real-time

Hardware Components

There are several individual components of an EMIS. This section provides an overview of each component. Some components may be part of the existing building infrastructure or may be shared with other systems common to commercial buildings.

Energy Meters

The U.S. Department of energy has published an extensive metering best practices guide that contains workable definitions for the various types of energy meters (Sullivan, et al. 2011).

Advanced meters have the capability to measure and record interval data and communicate the data to a remote location in a format that can be easily integrated into an advanced metering system. In terms of EMIS, these are whole building energy meters that are typically used by utilities to satisfy Federal regulations. Whole building utility meters typically provide measurement, recording of intervals and communication of the following resources:

- Electricity (kW, kWh)
- Natural Gas (therms)
- Water (gal, gpm)

An advanced metering system collects time-differential energy use data from advanced meters via a network either on-request or by scheduled delivery. While advanced metering systems are generally used by utilities, large mult-building customers such as universities and government agencies may have their own metering networks for disaggregating energy use across a portfolio.

System level energy meters are used to measure energy use within a pre-determined system boundary. They can either be part of a pre-existing building management system or installed specifically as part of an EMIS solution. Examples of system level meters include:

- Btu meters for determining HVAC loads
- Current transducers (CT) for measuring electric loads (eg. fan and pump drives, lighting panels, etc)
- A combination of temperature and mass flow sensors for calculating energy use

Sensors, Actuators, Transducers and Relays

Modern commercial buildings are typically equipped with a control system that is responsible for operating the building's thermal comfort and fire-life-safety systems. These systems carry out the majority of their work via a network of sensors, actuators and relays. In terms of the control system, sensors represent data inputs and actuators represent outputs. Transducers are used to convert control signals between carrier types and relays are used to switch electrical equipment on and off. Each of these devices has the ability to provide data to an EMIS either by interfacing directly with the device itself or indirectly through data collected by an existing control system.

CONTROLLERS

Modern direct digital control (DDC) systems are composed of a distributed system of small, computers. These devices are commonly referred to as controllers. Controllers are generally interconnected via a wired control network; however, this is not a requirement. Connectivity provides the ability to send and receive data between controllers.

Global controllers have resident memory so that they can recover after a planned reboot or power failure. They have three primary functions:

- Storage of control logic, often encapsulated in a computer program
- Send and receive control commands to field controllers
- Store data sent from downstream devices

Field controllers are less sophisticated and therefore contain less complex hardware than global controllers. They are used to control one or more individual pieces of equipment and receive their control commands from a dedicated global controller. A global controller may have many connected field controllers, while a field controller is connected to only one global controller. More detail on controller configurations is provided in Figure 4.

As opposed to interfacing directly with a network of sensors, actuators, transducers and relays, an EMIS may connect directly to a controller in order to collect data or send control commands. Furthermore, a network of controllers may provide the breadth of data required by an EMIS concerned with whole building energy.

NETWORK

A computer network is a collection of hardware components and computers that are interconnected by wired or wireless communication channels. The network allows information to be shared data between the connected devices. The physical network connections may be composed of commonly used Ethernet cable (e.g. CAT 5/6) or a pair of twisted copper wires. More detail on network configurations is provided in the System Architectures section of this report.

An EMIS may use an existing local area network (LAN) to collect information on a single building, or a wide area network (WAN) to oversee multiple buildings. Generally, the networks are part of a facilities pre-existing infrastructure either as part of a dedicated building automation system network or general use computer network.

The internet may also be considered to be part of the network used by certain types of EMIS. Internet connectivity may allow for:

- Transport of energy data to remote locations
- Hosting of websites that consist of energy dashboards, administrative controls
- Access to web-based services such as weather data, up-to-date energy costs and demand response events

Workstation/Server

Depending on the architecture of the EMIS, a computer terminal may provide one or many combinations of features. Functionality includes:

- An operating system for the EMIS software
- Administrative and energy reporting interface
- Persistence of energy measurement and results
- A web server for providing remote access to the EMIS application

Presentation

An EMIS workstation is commonly the central point of user interaction that provides reporting and visualization features to facility managers; however, there are other user interfaces that these systems offer, such as:

- Basic and comprehensive energy dashboards
- Web applications
- Email or SMS alerts and reports
- Images or mixed media containing charts and graphs
- Smartphone application interfaces

Data Persistence

The most critical component of an EMIS is data. Data can be stored in using a number of standard approaches:

- Local to the EMIS workstation in a database
- On a dedicated database server, either local or remote
- Uploaded to a remote data storage service supported by the EMIS software
- Stored in the database of an existing building automation system.

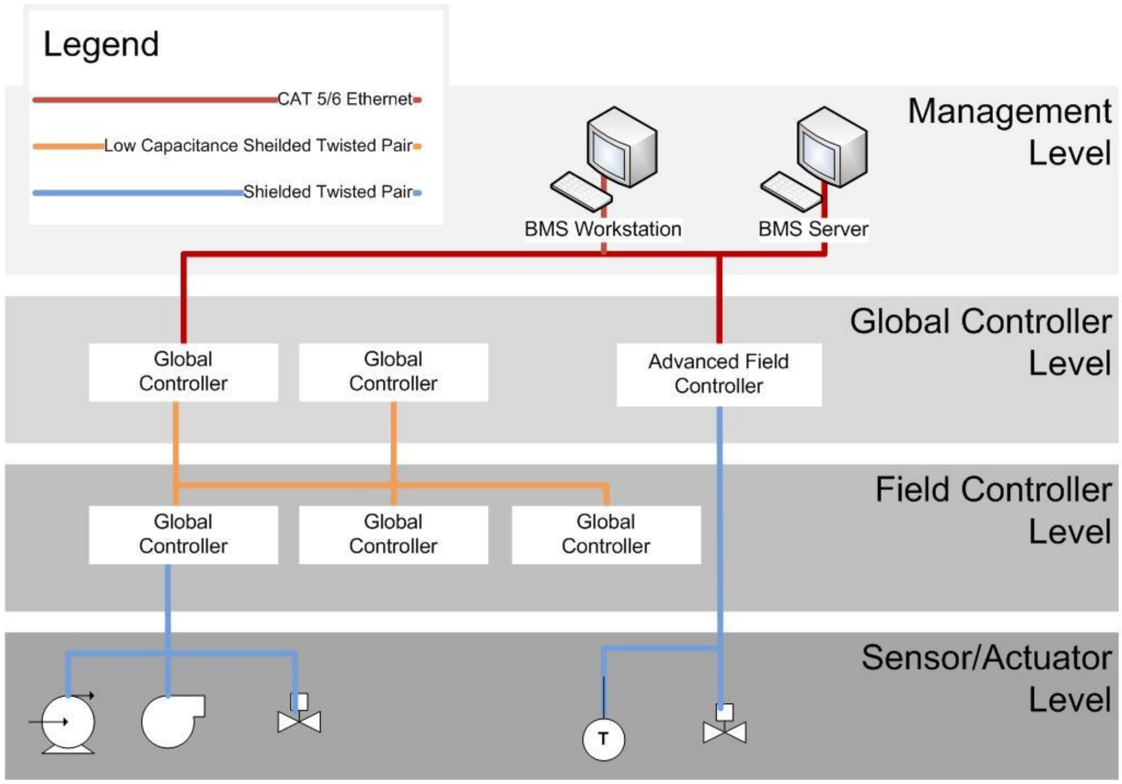
The persistence layer of any EMIS is typically determined by the software vendor or product.

System Architectures

EMIS architectures generally fall into one of five architecture types, each with their own inherent advantages and disadvantages.

Figure 4 represents a conceptual schematic of a simplified building automation network architecture. An EMIS solution can be integrated with the system at any level.

FIGURE 4 SIMPLIFIED BUILDING AUTOMATION NETWORK ARCHITECTURE



SOFTWARE ONLY

The existing infrastructure of a modern, DDC, building management system can be shared to provide the necessary components of an EMIS focused on whole building and system level energy.

Depending on the capability of an existing building automation system, some EMIS products consist of additional software packages that run on an existing BAS workstation. These systems use the entire existing hardware, network and data infrastructure.

ADVANTAGES:

- Uses existing hardware infrastructure such as sensors, network and computing power
- Leverages architecture familiar to building operators and controls engineers
- Tight integration and close proximity between building automation system and energy management systems may allow systems to interact at the software level allowing for additional optimization or automation features.

DISADVANTAGES:

- Systems are tightly coupled. Additional demands of EMIS may destabilize existing system and vice versa.

- Existing infrastructure must be compatible with EMIS solution.
- Data (trending) requirements of EMIS solutions are typically much higher than a building automation system. Network must be able to handle additional bandwidth to satisfy EMIS data scope and interval.

NETWORK HARDWARE

Another common integration approach is the use of a parasitic hardware device that is spliced into the control network at the management level. Such devices can passively sniff the network traffic generated by a control system and in some cases they can interact with the controllers directly in order to trend additional data or discover control parameters.

Data obtained by these devices is typically provisioned for additional analysis one of two ways; The device can be equipped with the necessary hardware to perform the operations onboard or it can upload the data to a dedicated workstation.

ADVANTAGES:

- Re-uses existing infrastructure
- Easy to install
- Multiple devices can be installed to monitor targeted subsystems

DISADVANTAGES:

- Existing controls protocol must be supported by device; older or less popular building automation systems may not be supported
- Translation and discovery of controller data is not always automated and must be done manually
- Systems can only passively report on energy use and is unable to actively optimize or alter control parameters

STANDALONE SYSTEM

Standalone systems are used where integration with an existing building automation system is not possible. They may be suitable for applications where a facility is still using pneumatic control or if a late model DDC system is not capable of interfacing with modern hardware or protocols.

ADVANTAGES:

- Standalone systems are engineered for specific needs
- Ideal for large installations where mixed building automation hardware makes integration difficult
- Improved reliability; EMIS is decoupled from building automation system so that one system is not dependent on another

DISADVANTAGES:

- Redundant systems and hardware increase costs and may be difficult to justify when modern building management systems share many of the characteristics
- System is not designed to ensure interoperability with building automation systems and equipment
- Requires specialized training for installation and ongoing management and may require additional, dedicated energy staff for oversight.

BUILDING AUTOMATION SYSTEM SOFTWARE MODULE OR PLUGIN

Several established BAS vendors offer a variety of additional modules that provide additional functionality to an existing system. These modules extend the usefulness of the BAS by providing features that are not within the purview of a traditional automation system.

ADVANTAGES

- Modules are often just additional software and can be easily installed
- Customer can be assured that module is fully integrated with the existing BAS
- Building operators accustomed to working with the existing BAS may find new module features to be more intuitive than learning a new system.

DISADVANTAGES

- Customer is locked into using the BAS manufacturer's proprietary software – this often undermines competitive pricing
- Additional modules are not likely interoperable with other systems not sold or supported by the vendor
- Modules features can be limited in scope and may require the purchase of additional modules that provide the desired feature set.

SYSTEM-LEVEL ADD-ON

Where only system-level energy information and management is desired, system or equipment focused solutions are used. These systems are installed at the field controller or sensor/actuator level.

ADVANTAGES

- Addresses a specific need for isolated systems
- Eliminates the complexity of integrating a whole building system

Disadvantages

- Interoperability with other system-level EMISs or building automation system is not always guaranteed
- Some systems are part of a niche market. Future support of the product may be questionable
- Identified energy savings may be too limited for smaller systems.

Software as a Service

EMIS solutions that adhere to the software as a service (SaaS) model are becoming a popular option given the ubiquity of internet connectivity at the majority of commercial buildings. SaaS-based EMISs receive data one of two ways. Software can be installed in parallel with an existing building automation system in order to facilitate the periodic uploading of trend data via an internet connection. The second approach involves an additional piece of dedicated hardware that interfaces with the building automation system and its database in order to periodically poll for new data and upload small batches of data at a time using a wired internet connection.

Advantages

- Most of the IT burden of a comparable in-house system is outsourced. Saves operational costs.
- Accelerated feature delivery. Customers receive automatic software updates without changes to their local systems
- User interface built with familiar web standards (HTML, JavaScript, CSS) using web application frameworks that typically provide integration with other systems that may provide additional functionality beyond those offered by EMIS solution.

Disadvantages

- IT policy for external network connectivity and data sharing can be complex for secure facilities (finance, government, municipal, etc.).
- Data and analysis results are controlled by EMIS provider – licensing model is different than traditional, perpetual software licensing
- SaaS applications are hosted far away from the customer. Latency issues may result if EMIS requires large amounts of data to be transferred electronically

Technical Features

EMIS solutions offer a variety of technical features intended to provide customers with enhanced energy information and management capabilities. Eight discrete, EMIS features are discussed below.

Energy Normalization

The normalization of a building's energy use is an approach used to add context to measured energy data so that it conforms to a standard for camparison, e.g. so it represents energy typically used in an average year for the same location. Energy use can be normalized against any number of independent variables that affect a building's energy use. While univariate regression models that use only outside air temperature as the independent variable are most common, other measured variables can also be used, including:

- Weather and climate data
  - Relative humidity
  - Solar Radiation
  - Wind Speed
  - Soil Temperature
- Categorical data
  - Building Occupancy
  - Building Schedule
  - Day of week
  - Season
- Customer specific data
  - Production
  - Tenant churn
  - Tenant improvements

Benchmarking

Energy benchmarking can be conducted in concert with energy normalization; however, it can also be performed using only key facility characteristics. Benchmarking provides a comparison of system or whole building energy metrics to industry standards, analogous systems or buildings, or previous measurements made under similar conditions.

Reporting

EMIS solutions typically offer energy reporting features that can range from simplified monthly usage and demand totals to sophisticated visualizations showing the results of energy analysis. Reports are tailored to a specific audience or stakeholder. In some cases configuration and delivery options can be customized to suite the customer's needs.

The reporting capacity of an EMIS is directly correlated to the system's data scope and interval. For example, reporting on time varying pricing requires that a system have both cost data and a data interval short enough to capture the variations – likely an hourly data interval or shorter.

Advanced Energy Modeling

Advanced energy modeling builds on the principles of energy normalization and benchmarking in order to create reliable energy models that are able to accurately predict a building's energy use. Government funded software, such as the U.S. Department of Energy's DOE-2 software, have demonstrated that both performance and prescriptive-based energy modeling software is an effective option for building energy use and cost analysis.

The value propositions of proprietary systems that provide advance energy modeling techniques are twofold. First, it provides a customer advanced warning of energy events or anomalies. Then based on the predictions, the customer has an informed opportunity to implement changes to their facility or operating procedures while being able to quantify the expected energy and cost savings.

Anomaly Detection

Anomaly detection analyzes patterns in whole building energy use for a given period and indicates that observations or measurements do not conform to expected values and are found to correlate with other factors such as weather conditions, building occupancy or schedules. The intent of anomaly detection is to provide actionable items to the customer using a top down approach by analyzing energy use from a whole building perspective.

Fault Detection

Using a bottom up approach, fault detection aims to identify issues at the system level. Systems using this methodology typically provide:

- The piece of equipment or system where the fault was detected
- An enumerated list of possible causes or potential remedies
- An estimated or measured amount of additional energy the fault is causing the system to use

Direct System Control

Direct facility system control is a feature that automates the control of building systems. While modern building automation systems provide control over most systems, the sequence of operations typically optimize for tenant comfort with little regard for energy consumption.

Parameter Optimization

Parameter optimization is a feature that allows the building control systems to optimize on multiple parameters. The building automation software is either designed to interact with the EMIS software executing the changes or the EMIS must consist of a specialized device that performs the control itself.

For systems that are already optimized for thermal comfort, an optimized parameter control system must perform analysis on multiple independent variables in order to meet both comfort and energy savings goals.

Encumbrances and drivers to broad EMIS adoption

To better understand the technological barriers and drivers that coincide with EMIS adoption, an exploration of the market landscape has been conducted. This analysis focuses on the perspectives of the broad range of customers that exist in the commercial building market. This section identifies common customer attributes and provides a generalized approach for characterizing prospective EMIS customers in the commercial building market.

In addition to grouping customer attributes, the characterization framework establishes a basis for identifying the barriers and drivers faced by new and existing customers in the EMIS marketplace. In later sections, this information will be used to identify key EMIS savings predictors and provide recommendations on additional research including field testing of EMIS system for the defined customer classifications.

Analysis provided in this section is based on a detailed literature review of research papers and articles that cover topics including energy management systems, performance tracking of commercial buildings, retro-commissioning (RCx), and energy metering guidelines. Additionally, as part of this research project, PG&E has provided the results of a focus group study on EMIS[1].

Size

Customer size is can be defined using a number of properties such as building square footage, number of employs or annual profits. With respect to energy efficiency, a customer's average peak demand is commonly used metric that combines all of these concepts into an easy to understand attribute.

- Small: Under 200 kW
- Medium: 200 – 1000 kW
- Large: Over 1000 kW

[1] The findings from these focus groups were summarized by Freeman, Sullivan & Co. PG&E shared these summaries with Enovity as part of this research project.

With respect to adoption, large customers have expressed the need for the availability of benchmarks that would show how an EMIS could be used for regulatory compliance. Large customers may need to comply with outdoor air quality regulations for example. A benchmark of how an EMIS may be used to achieve the compliance goals of a customer may be a driver. Medium and small customers report that oversight of monthly energy bills and enforcing sound energy habits for employees are the extent to which current energy efficiency is practiced.

AWARENESS

While energy efficiency awareness is often a function of a customer's size, other factors may contribute to the degree with which a customer has been familiarized with the benefits of energy efficiency. *Sophisticated* customers are organizations that are already using EMIS and are actively involved in energy efficiency projects. Customers with an *intermediate* level of awareness may be cognizant of the potential of energy efficiency projects, and may have undertaken energy efficiency focused projects; however, they lack the either the infrastructure or organizational tools to address energy efficiency in a persistent fashion. *Basic* customers possess little to no awareness of how energy efficiency can benefit their organization. These customers often share a number of other common attributes – namely they are often small organizations with limited resources dedicated to energy awareness.

SECTOR

The market sector of prospective EMIS customers is a subjective characteristic that has a strong correlation with how energy efficiency is managed and approached. The following commercial customer markets are considered:

- Non-Profit Organizations
- Healthcare services
- Hospitality services including hotels and residential
- Food service and warehousing
- Government
- Franchises

Market sectors have identified barriers that are specific to their marketplace. While each segment may see their limitations to approaching energy efficiency projects as unique, the root cause is often the result of prioritizing tenant comfort over energy efficiency. The healthcare industry is limited by the sensitivity of the environments they oversee as well as the regulations that govern their daily operations. In the hospitality industry, customer comfort is paramount and not likely to be tested for the sake of efficiency.

Property Type and Role

There are two property types that impact how an organization might approach energy efficiency. Furthermore, the type of property in combination with the role a prospective EMIS customer is in will play a large part in determining expectations. The following property type and role combinations are relevant:

- Managed Single Tenant Properties
- Managed Multi-Tenant Properties
- Leased Single Tenant Properties
- Leased Multi-Tenant Properties

For property managers, tenant expectations are often dictated by the market. A renter's market may limit the scope of energy efficiency efforts. Conversely, tenants have reported that existing lease agreements make initiating energy efficiency improvements on their own difficult. Such projects are limited to efficiency measures that are in the tenant's domain such as lighting systems.

However, both property managers and lessees have reported that a major driver in this category is the level of differentiation offered by energy rating systems such as Energy Star and LEED. Property managers have reported that spaces with a respected energy mark are more likely to command a higher price per square foot, while tenants see that occupying recognized real estate benefits their public image as well.

Personnel

Management, operations and facility personnel are important factors to consider when it comes to the adoption of EMISs and the execution of energy efficiency projects. Energy efficiency has placed new set of demands on all aspects of the people that work in the commercial building industry.

A major barrier reported by all stakeholders in the market is education. Existing building operators and facilities managers are not likely educated to address energy efficiency and not always aware of opportunities for ongoing education. The use of a modern, computerized EMIS presents a considerable technology barrier for seasoned operators that may have started their carrier well before the advent of direct digital control.

While energy efficiency oversight presents a new set of responsibilities, it can be used to incentivize operations staff and offer an added sense of ownership. Facility managers have reported that engaging operations and maintenance staff in department-wide competitions have helped to engage both employees and tenants in energy efficiency initiatives.

Management

There are two fundamental approaches currently employed when it comes to managing energy efficiency projects within a company. Top-down methodologies begin at the executive and corporate levels and are used to mandate broader, company-wide energy efficiency objectives. A bottom-up approach begins at the facility management or operations level and focuses on a narrow scope of issues including: tenant comfort, asset management, and system optimization. Commercial customers may utilize a combination of these energy management approaches.

The ongoing management of energy efficiency is an important subject that has received wide spread attention. In a 2011 report[2], Accenture examines a pilot program that uses EMIS technologies by Microsoft's Real Estate & Facilities organization and cites a major inhibitor to adoption as being "the need for full commitment and close collaboration between all stakeholders" including executives, building engineers, IT staff and external vendors. How each of these entities is managed is not only a challenge but often requires a shift in strategies.

Barriers from a bottom-up perspective focus on management of day-to-day operations and how to manage energy efficiency. EMISs are believed to require intensive oversight because the amount of data they produce. Building engineers have reported that skepticism exists regarding the amount of actionable data that such a system can produce on a regular basis.

Both approaches are often barriers in and of themselves. When energy efficiency initiatives are dictated from the top-down, facility staff can be left with additional responsibilities – added accountability that they might not be accustomed to. Conversely, bottom-up management will have a difficult time getting support for additional energy efficiency projects that are out of scope of traditional budgeting or resourcing concerns.

Drivers to adoption include the possibility of enhanced building automation. Automation is believed to provide reductions in operating costs. Facilities managers have also reported that an automated system that is able to track energy use us helpful in monitoring the habits of facility staff. For example swing shift staff may operate a building in a different manner than the day shift, or they may override automated controls to troubleshoot comfort issues.

POLICY

Corporate policy can be both a barrier and driver of energy efficiency. A policy that actively addresses energy goals is more likely to infiltrate all aspects of an organizations management, operations and culture. Conversely, in the absence of a company-wide campaign, individual efforts to improve, mitigate or identify energy efficiency issues will find it challenging to overcome the inertia of the organization's status quo.

An example of the effects of corporate policy on energy efficiency is highlighted in franchise organizations. Potential EMIS customers that own one or more branches of a franchise have reported that their options are limited by corporate policy. A

[2] http://www.microsoft.com/environment/our-commitment/greener-it.aspx

potential driver could then be assumed that changes to corporate policy, in favor of energy efficiency, may result in broad EMIS adoption.

Economics

The economics of both energy efficiency projects and EMIS adoption are directly related to the cost of energy, i.e., the less a facility's operating cost is driven by energy, the less interest there is in pursuing energy efficiency. Investment criteria of energy efficiency projects may vary; however, the core drivers include simple payback and life-cycle cost. These concepts become more difficult to evaluate when the initial cost of a project increases due to the addition of an EMIS. The added benefits of ongoing commission and the assertion of cost savings are not common investment or evaluation criteria.

Product

The adoption of EMISs in the existing commercial building marketplace is impeded by several factors. Often these factors are compounded by barriers that exist in other areas such as the education of operations staff or how managers will utilize a given product to carry out their energy efficiency objectives.

First, EMISs represent another change to an industry that is still in the process of embracing the virtues of direct digital control (DDC). While vendors attempt to differentiate their products with descriptive terminology, prospective customers are confused by the new vocabulary. In many cases, building operators are still in the process of learning to support and tune DDC systems and the addition of another computerized system may be seen as overkill.

Potential investors have also expressed concerns regarding the shelf life of EMISs. The majority of software-based systems require strict licensing terms for basic operation and upgrades. Ongoing technical support is also an issue when in-house expertise is not available.

Lastly, the maintainability of EMISs on long-term effectiveness of the system to deliver persistent energy savings is often unproven. Often customers are introduced to new products that do not have a proven track record. As with any consumer the benefits of an EMIS are regularly met with skepticism.

Emerging Technology/Product

The preceding sections of this report have covered the major attributes of energy management and information systems; the various product architectures; a list of the common features available in the current product landscape; a general framework for characterizing EMIS solutions; and a market analysis summary of the key barriers that prevent broad EMIS adoption for different segments of commercial utility customers. This section of the report will clarify how EMIS implementation can benefit commercial utility customers and potential sources of leverage that a utility can impart to effect and accelerate adoption of such beneficial technologies.

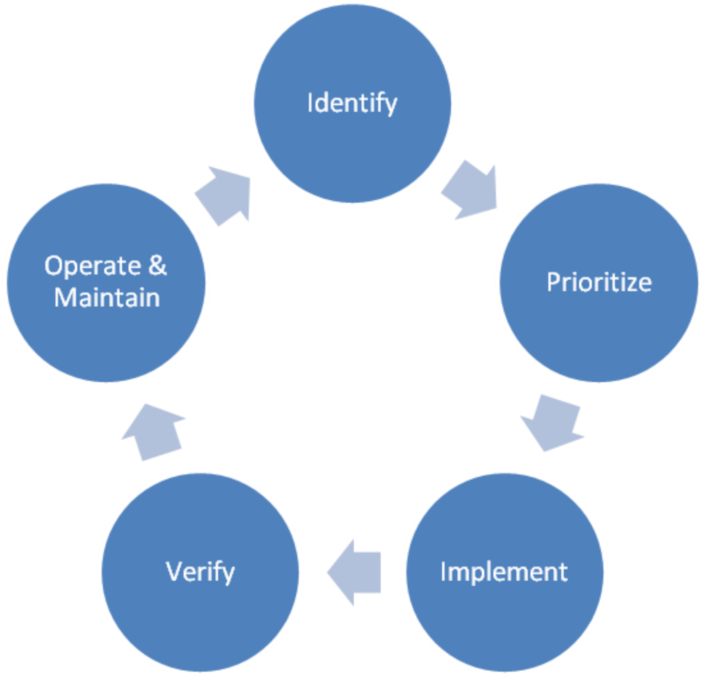
While potential customers may possess similar objectives when it comes to leveraging an EMIS to pursue energy savings opportunities, the vast combinations of customer attributes and product capabilities create complexity. This section will discuss the high-level savings measures and the enabling attributes of both the EMIS product and the customer. Additionally, applicability of each product classification will be addressed in each phase of the energy project lifecycle.

Energy Project Lifecycle

The energy project lifecycle describes the process by which savings opportunities are identified, prioritized, implemented, verified, and operated and maintained. Specific features common to each of the identified product classifications can enhance each step of the process. In this respect, energy management and information systems supplement energy projects as a tool by which to achieve energy savings.

The five phases of the energy project lifecycle represented in Figure 3 historically start with the identification of energy savings opportunities, continue through opportunity prioritization, implementation, energy savings verification, and conclude with operation & maintenance, which continues until the end of the project's useful life. This may be repeated for as many cycles as deemed necessary in order to address changes a to a building's energy demand. In many cases, the operation and maintenance of an energy project leads to deeper savings by increasing the prominence of additional opportunities in the form of unaddressed building loads. Implementation of EMIS systems that persist with a facility over time offer the opportunity to originate and/or benefit ongoing projects at all points of the project lifecycle.

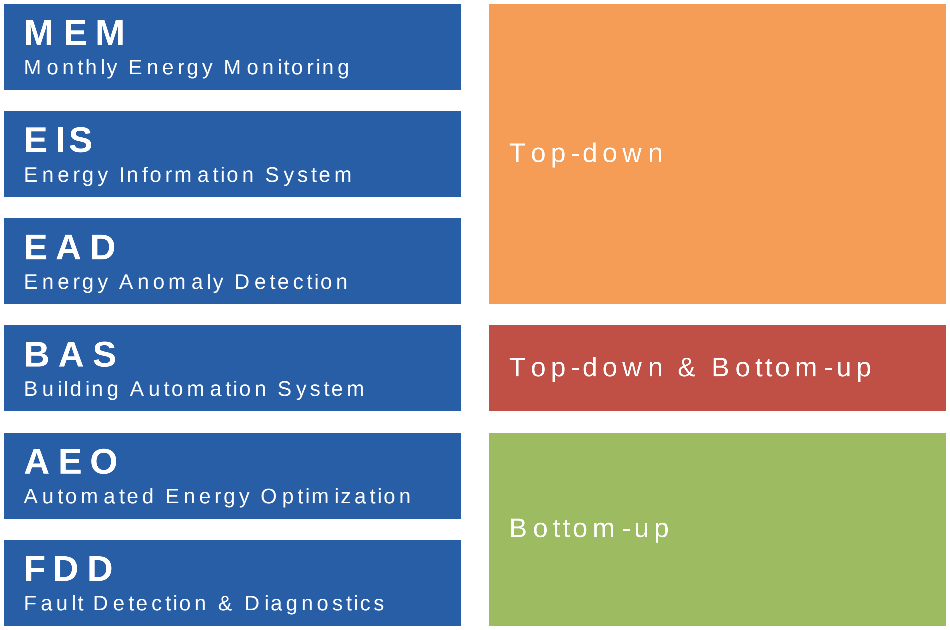
FIGURE 3 ENERGY PROJECT LIFECYCLE



IDENTIFY

The first step in pursuing energy savings is to identify the areas where opportunities may exist. Historically, the most prevalent method for identifying efficiency opportunities is through the physical observation of a facility's existing assets and operating characteristics opportunities. EMIS tools offer the promise of automating the discovery of energy projects in commercial buildings through two general approaches referred to as **top-down** and **bottom-up**. These concepts are shown in relation to the EMIS product stack in Figure 4.

FIGURE 4 EEM IDENTIFICATION: TOP DOWN & BOTTOM UP



The top down approach focuses directly on energy use/demand, often at the whole-building level, and presents this information to identify energy opportunity potential. One of the most basic tools in a top-down approach is the monthly energy bill. Higher levels of data resolution such as short interval data measurements at the building and/or subsystem levels offer increasing insight into the potential energy opportunities in a facility. The strength of the top-down approach is that it focuses on intended effect (energy use), but its weakness is the lack of focus on the direct causes of energy use (facility operation). Focusing too narrowly on energy use may not provide the information need to identify a specific project that results in an energy saving opportunity.

The bottom up approach focuses directly on facility operation at the equipment and system level and presents this information to identify projects. One of the most basic tools in a bottom up approach is an equipment alarm. Higher levels of data resolution such as direct measurement of system operating parameters at the equipment and system levels increase insight into the operation of facility. The strength of the bottom-up approach is that it focuses on the direct causes of energy use (facility operation), but its weakness is the lack of focus on the intended effect (energy use). Focusing too narrowly on facility operation may not provide the feedback needed to understand how a specific project affects energy use.

PRIORITIZE

After a collection of EEMs have been identified, customers must be provided with additional information that will allow them to prioritize which measures are carried into the next phase of the project lifecycle. The prioritization criteria used to determine which measures receive the most attention typically varies from customer to customer. However, prioritization criteria commonly include one or a combination of the following:

- Magnitude of energy savings
- Simple payback or life cycle cost
- Priority of affected systems
- Ease or complexity of implementation

In general, the primary feature provided by the majority of EMIS products is an indication of the projected energy savings potential. Data scope and interval limit the quality and granularity of the savings estimates.

IMPLEMENT

Implementation of an EMIS can have both direct and indirect effects on energy use. In the case where the EMIS focuses on reporting does not have any direct system control, the contribution to energy efficiency is indirect. As a corollary to the way an EMIS is used in the identification phase, the same notification mechanism (or the absence thereof) can serve to identify when a fault clears or when an energy "anomaly" occurs in a favorable direction.

For EMIS products that have direct system control, e.g. BAS and AEO, the implementation of the product is integral and directly associated with energy savings since their presence provides the mechanism to automate and optimize system operation for ongoing energy efficiency.

VERIFY

The measurement and verification process (M&V), drawing from standard industry terms from the International Performance Measurement and Verification Protocol (IPMVP) framework, can benefit from the presence of EMIS in a variety of ways. A whole building approach (IPMVP Option C) is comparable to the top-down measure identification approach and may be used to verify savings using energy data collected at the building's main utility meter. Conversely, retrofit isolation (IPMVP Options A & B), is a bottom-up method for verifying energy savings at the system or equipment level using in-building data from a BAS.

Data scope and interval enable the EMIS to be used as a verification tool. EMIS with the ability to measure energy consumption either at the whole building or system level may be used to analyze and report the difference in energy consumption (i.e. energy savings) before and after the implementation phase.

OPERATE & MAINTAIN (PERSISTENCE)

The value proposition of most EMIS products on the operation and maintenance of an energy project or facility is energy savings persistence (i.e. verified energy savings will extend beyond the current project cycle whether through direct or indirect means). Direct persistence results from the implementation of a robust EMIS with direct system control. Indirect persistence results from an increase in awareness of energy use through the reports and notification features of an EMIS.

Energy savings persistence, enabled through the utilization of the EMIS to operate and maintain system function, also serves to increase the prominence of new efficiency measures that may have been previously obscured by "low hanging fruit". To expand this metaphor, EMIS can serve to effectively "lower the tree" and help identify projects for consideration in the next iteration of the energy project lifecycle.

APPLICATION OF THE EMIS WITHIN THE ENERGY PROJECT LIFECYCLE

This section lists a further breakdown of potential ,strengths, weaknesses, savings opportunities and the intended audience(s) of each category of EMIS relative to each phase of the Energy Project Lifecycle.

IDENTIFICATION

MONTHLY ENERGY MONITORING SYSTEMS

Strictly top-down

Identify savings opportunities through reporting, energy normalization, and benchmarking.

Reports include monthly and/or seasonal energy use

Energy may be normalized to show seasonal effects

Benchmarks show energy use between two or more metered buildings or may show comparison with buildings of similar size and occupancy

Requires whole building meters for each energy source

Savings opportunities:

- Building schedule tuning
- Seasonal adjustments for energy use

Intended audience is accounting personnel because of energy cost data scope and monthly energy use focus

ENERGY INFORMATION SYSTEMS

Mostly Top-down

Identify savings through energy normalization and benchmarking

Requires whole building meters for each energy source

May have energy reporting features for other end uses but generally utilizes top-down approach

Savings opportunities:

- Building schedule tuning
- Zone scheduling adjustments

Intended audience is energy managers, executives and tenants

Energy Anomaly Detection Systems

Top down energy optimization

Product is the identifier

Advanced energy modeling may be used to predict anomalies

Building Automation Systems

Combines both top-down and bottom-up approaches

Identifiable savings opportunities

Equipment schedule tuning

System control optimization

Audience is building engineers, energy managers and operations personnel

Advanced Energy Optimization Systems

Product is the project identifier

Bottom up approach beginning with system being optimized

System and hardware requirements are determined specifically by the product being installed

Fault Detection & Diagnostic Systems

Strictly a bottom-up tool

Identifies savings opportunities indirectly through enumerated list of faults

Requires specialized expertise to identify savings potential of each fault

System may provide estimates of savings based on characteristics of affected equipment and systems

Prioritization

Monthly Energy Monitoring Systems

Prioritized based on cost of energy or comparison of benchmarks

Energy Information Systems

Based on magnitude of predicted savings using benchmark comparison

Energy Anomaly Detection Systems

Advanced energy modeling is used to determine magnitude of potential energy savings

Energy anomalies are compared to energy model to determine magnitude of energy avoidance in absence of anomalies

Building Automation Systems

Products do not provide prioritization features

Advanced Energy Optimization Systems

Products do not provide prioritization features

Fault Detection & Diagnostics Systems

Faults may include predictive savings amount

Faults indicate affected systems allowing additional prioritization based on other properties of affected assets

Implementation

Monthly Energy Monitoring Systems

No implementation

Energy Information Systems

Feedback from energy dashboard for behavioral or operational adjustments

Energy Anomaly Detection Systems

Used to alert operators of significant events that effect energy use

Building Automation Systems

Most common product for implementing energy efficiency measures

Implemented via direct system control

Advanced Energy Optimization Systems

Product is the implementation

Minimizes energy use while maintaining quality of other criteria

Fault Detection & Diagnostics Systems

Notification of system faults providing opportunity for ongoing maintenance and optimal operation of existing systems

Verification

Monthly Energy Modeling Systems

Top-down, whole building approach

Verifies savings are realized and persisted at monthly or seasonal intervals

Energy Information Systems

Top-down, whole building approach

Energy Anomaly Detection Systems

No standard verification option used
Ensures adverse anomalies are consistently handled and persisted

Building Automation Systems

No standard verification option used
May use reporting capabilities to facilitate Options A or B

Advanced Energy Optimization Systems

No verification

Fault Detection & Diagnostics Systems

No standard verification option used
Assertion that previous faults do not repeat

Maintenance & Operation (Persistence)

Monthly Energy Monitoring Systems

Monthly energy use
Persistence of cost savings and monthly energy use
Comparison to previous benchmarks

Energy Information Systems

Ongoing reporting of whole building energy

Persistence of changes to load profile changes

Graphical/tabular comparison of current energy use to benchmark

Energy Anomaly Detection Systems

Alerts operators to energy events

Assert that energy events addressed in previous projects are accounted for

Identification of unhandled events

Building Automation Systems

Automation of operation ensures consistent operation of building systems

Ensures persistence of automated sequences

Advanced Energy Optimization Systems

Automated system optimization

Automation ensures persistence

Fault Detection & Diagnostics Systems

Fault detection

Identifies pool of unhandled faults as compared to previously addressed faults

Assessment Objectives

Recommended Pilot Projects

Automatic Demand Control

Objectives

Promote continuous automated customer demand control in response to real-time customer-specific energy use and pricing.

Enablement

Distinct from Automated Demand Response, this program offers customer specific energy demand feedback and pricing signals in real-time to implement demand control measures in real time on a continuous basis and integrate EMIS with existing utility meter data. A key aspect of this pilot is to provide this utility-metered data in an open protocol as that allows customers to automate their facility systems and utilize cost/energy use as direct feedback in real-time.

Process

EMIS solutions have the potential to benefit overall program cost-effectiveness and success through increasing energy savings, reducing program costs, or both. The pilot will explore opportunities to enhance program cost effectiveness and deliverables at each of the five points in the project lifecycle.

Identify

The strength of EIS/EAD is to interpret energy usage, provide insight, and identify when anomalies/changes occur in energy use. By identifying trends in energy use that coincide with utility peaks, the products can identify where opportunities exist to spread or reduce load during high demand conditions.

Prioritize

Coupling real-time energy cost data along with real-time energy use provides a potent incentive to reduce both energy and energy cost when electricity prices are high, particularly to those customers who purchase energy on a real-time pricing rate. Real-time pricing feedback empowers customers to prioritize how and when they use energy.

Implement

During initial project implementation, the pilot plays a key role by providing a communication and data interface for real-time energy usage and pricing signals. This interface may take place through physical relays/analog outputs provided by the utility at the customer's facility (similar to the open ADR relay interface currently available for Demand Response program participants) or through an open protocol directly from utility to the customer's control system through the internet.

On an ongoing implementation basis, the provision of energy usage and pricing information will provide customers with continuous actionable data to which their systems can respond.

Verify

The capabilities of EAD already give customers insight about trends in their energy use. The pilot will also explore opportunities for quantifying and evaluating the effectiveness of energy measures directly with the EAD tool(s).

Operate & Maintain

The program offers customers the ability to continuously and automatically modulate their facility operation based on real time costing data. This ability, coupled with an EAD that will inform and notify customers about changes in their energy use, provides a potent combination of information for customers to continuously operate and maintain their facilities in an energy cost effective manner.

INCENTIVES

Real-time customer utility meter demand and cost data interface in an open protocol for EMIS utilization to obviate need for investment in redundant real-time metering

Cash incentives to offset installation costs for technology to integrate demand and pricing signals with EMIS and demand control measure implementation

Subsidized purchase of EMIS product

Facility staff and management training focused on management and operation of automated demand control and EAD system

Consulting services to support implementation of the EMIS and assist the customer through the course of a full energy project lifecycle

Participant Roles

- Utility
  - Provides cash incentives
  - Provides metering and real-time demand and cost data in an open protocol
- Customer
  - Participates in the peak day pricing rate structure
  - Purchases EMIS
  - Implements demand control in response to pricing signals during peak demand periods
- Program Implementer
  - Identifies and prescribes demand control measures
  - Quantifies energy/demand savings
  - Performs customer assistance, service and program administration
- EMIS provider
  - Delivers value proposition of EMIS solution
  - Provides data presentation/interface with customer
  - Interfaces with utility data
  - Interfaces as necessary with local building control systems
- Customer Controls contractor
  - Implements demand control measures
  - Coordinates interface inputs/outputs with utility and/or EMIS provider

SUCCESS FACTORS

Provision of customer specific meter data and pricing information in real-time has long been one of the key value propositions of utility smart-meter implementation. One of the key outcomes of this pilot will be to address/overcome the technical/security issues that surround the prospect of providing data to customers and to customer authorized EMIS providers in an open source application program interface (API) that enables customers to implement demand control in real-time.

Utility customers have been slow to adopt real-time pricing (RTP) rates. A key premise of this pilot is that customers will opt-in to RTP rate plans if they are empowered with pricing information in a format that is actionable in real-time. Successful case studies from this pilot may prove useful as marketing materials to encourage customer participation in RTP rate plans.

EAD solutions offer customers estimates of energy and cost savings through proprietary algorithms that identify and quantify changes in patterns of energy use. One of the key aspects of this pilot will be to utilize and evaluate the ability of EAD as a tool to supplement the evaluation and validation energy savings for awarding incentives upon initial implementation and on a periodic basis over time.

Pricing models for current EMIS solutions that offer customer energy demand feedback typically includes the installation cost of installing shadow metering in their current pricing and business models. This cost, while good for customer retention by an incumbent EMIS, is a significant cost barrier for market adoption. Recruiting EMIS providers to adapt their business model for small scale pilot may be difficult as there will be initial data translation development costs that will likely exceed the cost of meters on a one-time installation. The program will test the expectation that EMIS providers will recognize the long-term opportunity to participate as early adopters/developers of an open automated demand control protocol or open source API that allows utility meter and cost data to flow to customer authorized EMIS solution providers and obviates the need for shadow meters.

EMIS System Attributes

Data Scope & Data Interval

Weather – Optional as input, weather is frequently useful as a predictor of energy performance

Whole Building Energy – Required as input in near real-time to measure the controlled variable

System Level Energy – Optional as input, can be useful for understanding impact of demand control strategies at individual system level

Cost – Required as input in parity with energy interval to determine financial benefit of implementing demand control

Control Parameters – Required as outputs in real-time as required to effect system demand (e.g. space temperature, space lighting level set-point resets, etc.)

System Performance – Required as a reference for tracking key performance indicators in parity with energy and cost data as well as optional inputs from independent predictive variables such as weather, day of the week, time of day, etc.

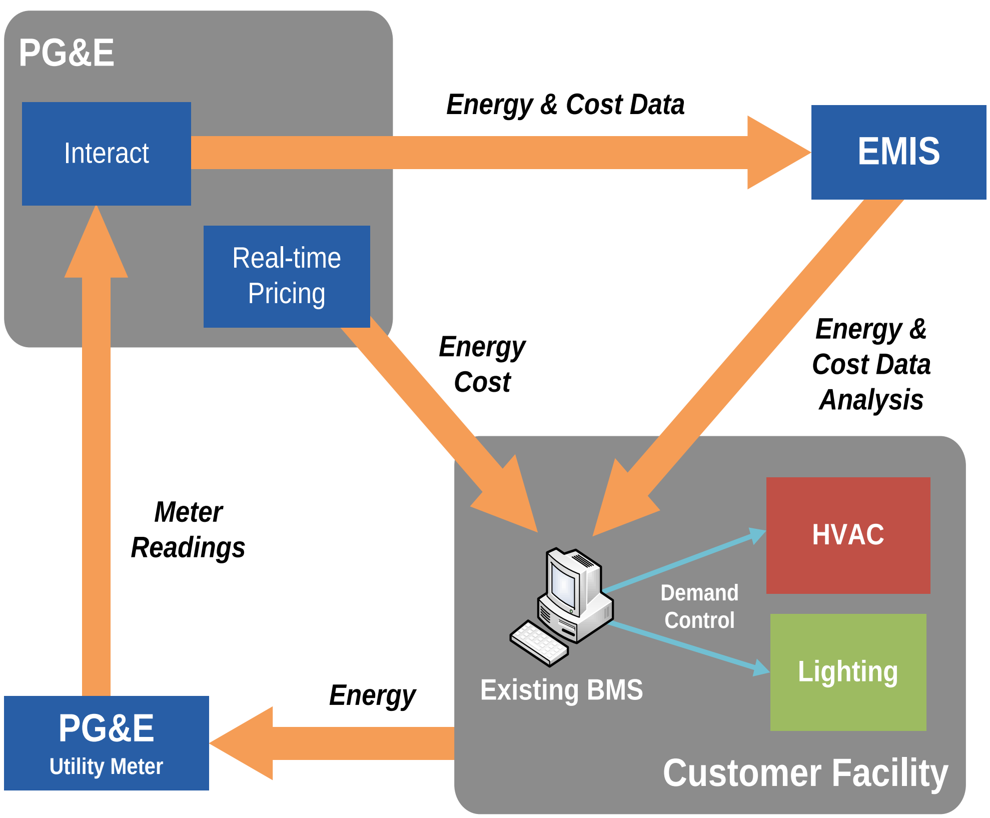
Hardware Components

Energy Meters – Most existing EMIS systems require the installation of standalone metering in addition to the existing the utility meter, which requires an investment by the customer in the form of direct installation costs or monthly service charges with an EMIS provider. Allowing the latent capabilities of the existing utility smart meter to provide near real-time energy/demand data from the utility in an open protocol obviates the need for redundant meters. Transparent and timely data will allow EMIS providers to standardize their products on the utilization of existing utility meter data and remove a significant cost barrier to their customers.

Data Transfer – A substantial portion of the purpose of the pilot is to develop a method for translating real-time energy cost and usage data into a secure and usable format for both EAD solution providers and local BAS systems. Solutions for this data interchange will require further investigation (as part of the pilot) and will likely include coordination and provision of some or all of the following components:

- Sensors, Actuators, Transducers and Relays
- Controllers
- Network
- Workstation/Server
- Presentation
- Data Persistence

FIGURE 5 AUTOMATIC DEMAND CONTROL INFORMATION FLOW



ENERGY ANOMALY DETECTION PAIRED WITH FAULT DIAGNOSTIC DETECTION

OBJECTIVES

Promote the correction of detected faults identified via Fault Diagnostic Detection (FDD) system by pairing with it an Energy Anomaly Detection (EAD) system in order to reduce the faults down to those corresponding with an energy anomaly. Energy savings will be verified use whole building approach (top-down).

ENABLEMENT

Incentivize initial cost for purchase, installation and training for applicable EAD system to identify periods where typical energy usage has drifted from expected values. Also, incentivize FDD system to identify faults on systems, sensors, and sequences of operation that can be filtered to show only those aligned with an area of anomalous energy use.

PROCESS

EMIS solutions have the potential to benefit overall program cost-effectiveness and success through increasing energy savings, reducing program costs, or both. The pilot will explore opportunities to enhance program cost effectiveness and deliverables at each of the five points in the project lifecycle.

IDENTIFY

The combination of the EAD (top-down) and FDD (bottom up) is the nexus of this pilot program. Historically, FDD has been strong on identification quantity, but notorious for providing false-positive fault detection. The combination of FDD and EAD offers the promise of reduced false positives by correlating faults with changes in energy use. Anomalies that coincide with faults and comply with program guidelines are deemed to be candidates for prioritization phase.

PRIORITIZE

The combination of FDD and EAD offers the promise of correlating faults with changes (anomalies) in energy use. To the extent feasible, the FDD & EAD output will, in addition to measure identification, provide the projected energy savings potential of bona fide faults. The program provides a basis for prioritizing measures by providing projected savings magnitude along with actionable faults

IMPLEMENT

During measure implementation, the Customer Mechanical/Controls Contractor will track the timing of measures as they are completed. The timing of project completion milestones will be compared with timing of fault correction as recognized by the FDD and the timing of energy anomalies (savings) as recognized by the EAD.

Verify

Similar to the measure prioritization process, the combination of FDD and EAD offers the promise of correlating faults with changes (anomalies) in energy use. To the extent feasible, the FDD & EAD output will provide the verified energy savings of fault corrections as recognized by the FDD and the magnitude of energy anomalies (savings) as recognized by the EAD. Measure timing and savings magnitude information may be used to disaggregate individual measure savings where whole building (Option "C") is used to quantify overall project savings.

Operate & Maintain

The program offers customers the ability to continuously monitor operational system faults. This ability, coupled with an EAD that will inform and notify customers about changes in their energy use, provides a potent combination of information for customers to continuously operate and maintain their facilities in an energy cost effective manner.

Incentives

Real-time customer utility meter demand in an open protocol for EAD analysis. Alternately, provide redundant real-time shadow metering necessary for EAD solution

Subsidized PURCHASE of supported FDD and EAD systems

Cash to offset installation costs for technology to integrate demand and pricing signals with EMIS and demand control measure implementation

Facility staff and management training focused on management and operation of FDD and EAD system

Consulting services to support implementation of the EMIS and assist the customer through the course of a full energy project lifecycle

Participant Roles

- Utility
  - Provides cash incentives and real-time demand in an open protocol
  - Customer
  - Implements corrective actions on faults (can be filtered to specific systems for cost control), purchases EAD software
- Program Implementer
  - Utilizes FDD to identify faults and prescribe energy measures
  - Quantifies energy/demand savings
  - Performs customer assistance, service and program administration
- EAD provider
  - Delivers value proposition of EAD solution

  - Provides data presentation/interface with customer
  - Interfaces with utility data, and interfaces as necessary with building automation system and/or weather data provider systems
- FDD provider
  - Delivers value proposition of FDD solution, provides data presentation/interface with customer, and interfaces with building automation system.
  - Customer Mechanical/Controls Contractor
  - Implements measures/faults and interface inputs/outputs with EAD/FDD provider.

SUCCESS FACTORS

The program will test the premise that EEM savings using FDD are detectable and quantifiable through the EAD. Reconciliation of the discrete outputs between two distinctly different EMIS solutions may prove to be too tedious task for widespread adoption by customers in practice, but a successful proof of concept demonstrated by the program could motivate the development and convergence of EMIS solutions that integrate the complimentary aspects of FDD and EAD

EAD solutions offer customers estimates of energy and cost savings through proprietary algorithms that identify and quantify changes in patterns of energy use. One of the key aspects of this pilot will be to utilize and evaluate the ability of EAD as a tool to supplement the measurement and verification of energy savings for awarding incentives upon initial implementation and on a periodic basis over time.

Coincidental faults and energy anomalies, when combined, may provide sufficient resolution measure and verify the incremental effects of small EEM measures. Where incremental effects are not discernable, additional interpretation of the data may serve to disaggregate and apportion the savings of individual energy measures that comprise an energy savings value calculated through the whole building (IPMVP Option "C") energy savings measurement and verification methodology. EMIS tools will be utilized where possible to substantiate and disaggregate whole building energy savings calculations.

PORTFOLIO FIT

EMIS System Attributes	
Data Scope	• Weather • Whole Building Energy
Data Interval	• Real-time OR 15-minute
Hardware Components	• Whole Building Meters • Other components may be required depending on EAD and FDD requirements and existing building infrastructure
Technical Features	• Advanced Energy Modeling (via EAD) • Fault Detection (via FDD) • Fault Reporting • Fault Cost (Optional) • Energy Anomaly Savings (Optional)
System Architecture	• EMIS architecture is dependent on customer's existing infrastructure.

ENERGY INFORMATION SYSTEM / ANOMALY DETECTION WITHOUT ADDITIONAL METERING

OBJECTIVES

Pilot demonstrations an EIS and EAD EMIS without the need for installing additional energy meters by utilizing existing utility meter interval data, interfaced directly with the EMIS or through the internet. This strategy may be more cost effective for small to medium commercial buildings. The pilot should conduct demonstration projects on multiple buildings of varying size and type, particularly small and medium buildings. Also, deploy and evaluate new strategies to provide EMIS data and analysis to building occupants, employees and operational staff for improved energy management and savings.

ENABLEMENT:

- Provision of real-time customer utility meter demand data in an open protocol for EMIS utilization to obviate need for investment in redundant real-time metering.
- Installation of EMIS, EIS or EAD applicable to all building sizes including small and medium.
- New strategies and technologies to share energy use data and EMIS results to the building occupants and operational staff.

- Energy savings for market segments where savings have been difficult to achieve.

Incentives

- Incentives to offset the cost for installing the EIS and EAD functions and where applicable additional strategies and technologies such energy kiosks to share data with occupants and building staff.
- Potential incentives for verified energy savings achieved after the installation of the EIS or EAD toolset, possibly with a tiered incentive structure to incentive deeper energy savings.

Participant Roles:

- Utility – to provide cash incentives and utility meter real-time demand to the EAD EMIS (to avoid installing an additional whole building shadow meter).
- Customer – installs EMIS and works with the EMIS vendor, Program Implementer and building occupants, employees and operators to analyze the results and achieve verified energy savings.
- Program Implementer – works with utility to identify and screen potential customers, works with the customer and EMIS vendor to evaluate the data and results, identify and evaluate energy/demand savings, and performs program administration.
- EMIS Provider – Delivers value proposition of EMIS solution and provides data presentation/interface with customer, and interfaces with utility data or meter. Also, provides customer training and works with the Customer and Program Implementer to evaluate the EMIS results and achieve energy savings.

Process

- Identify and screen potential sites.
- Implementation and training.
- Baseline energy development and model prediction.
- Energy savings implementation and verification.
- Energy anomaly detection, optimization of building operation and additional energy savings.
- Final energy savings verification.

Metrics or Success Factors

The cost effective deployment of top down EMIS aimed at small and medium customers and installing additional interfaces and display terminals. Verified energy savings through the EMIS.

EMIS SYSTEM ATTRIBUTES

Data Scope & Data Interval

- Weather – Required as an input, weather is frequently useful as a predictor of energy performance. .
- Whole Building Energy – Required as input in near real-time or the following day to measure the controlled variable.
- System Level Energy – Optional but not required.
- Control Parameters – Optional but not required.
- System Performance – Optional but not required.

Hardware Components

- Energy Meters – Most existing EMIS systems require the installation of standalone metering in addition to the existing the utility meter, which requires an investment by the customer in the form of direct installation costs or monthly service charges with an EMIS provider. Either allowing for access to the utility meter energy/demand data through the internet or through an open protocol connection eliminates the need for redundant meters.
- Operator Interface and Display Terminals / Kiosks – The EMIS interface and additional onsite display terminals and kiosks provide valuable information to the building managers, operators and occupants through energy dashboards and graphical displays of the data and load shapes. The software and information presented needs to be easy to use, with information that will impact the operation and behavior of the occupants and operators.

APPENDICES

REPORT ATTACHMENTS

Product Review Matrix	EMIS_Product_Review_Matrix.pdf

REFERENCES

Consortium for Energy Efficiency, Inc. "Summary of Commercial Whole Building Performance Programs: Continuous Energy Imporovement and Energy Management and Information Systems." June 2011.

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