Synthesis of Year One Outcomes in the Smart Energy Analytics Campaign

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Executive Summary

As building energy and system-level monitoring becomes commonplace, facilities teams are faced with an overwhelming amount of data. This data does not typically lead to insights or corrective actions unless it is stored, organized, analyzed, and prioritized in automated ways. Buildings are full of hidden energy savings potential that can be uncovered with the right analysis. With sophisticated analytic software applied to everyday building operations, building owners are using their data to their advantage and realizing cost-savings through improved energy management.

The Smart Energy Analytics Campaign is a public-private sector partnership program focused on supporting commercially available Energy Management and Information Systems (EMIS) and monitoring-based commissioning practices. The Campaign couples technical assistance with qualitative and quantitative data collection. Partnering participants are encouraged to share their progress and may receive national recognition for implementations that achieve significant energy savings.

The data in this report shows that owners representing over 185 million square feet of floor area are cost-effectively implementing EMIS, and the report presents a preliminary characterization of EMIS products, MBCx services, and trends in delivery to industry. This information will be updated based on continued data collection over the course of the Campaign.

Campaign participants have made improvements to their buildings, achieving a median energy savings of 5 percent for 400 billion Btu/year and $9M/year, based on 15 participants reporting. With cost reporting from nine participants thus far, the median cost for EMIS software installation and configuration was $0.04/sq ft, and the median annual labor cost (internal staff or contracted) was $0.08/sq ft resulting in a total first year cost of $0.12/sq ft. The median annual recurring software cost was $0.01/sq ft. These preliminary savings and costs lead to highly promising cost-effectiveness figures, with less than a 1-year simple payback.

Table ES-1 below summarizes Campaign results to date using data collected from 46 participating organizations. With respect to the EMIS family of technologies, partners in the Campaign have implemented 20 different energy information system (EIS) products, 7 fault detection and diagnostics (FDD) products, and 1 automated system optimization (ASO) product.

The high level of participation in the Smart Energy Analytics Campaign points to a growing national trend in the use of analytics in commercial buildings. The Campaign supports an expansion in the use and acceptance of EMIS, helping organizations move beyond data paralysis to building operations that are continuously informed and improved using analytics. More information about the campaign is available at https://smart-energy-analytics.org/.

Table ES-1. Summary of EMIS Use by Smart Energy Analytics Campaign Participants, through July 2017

EMIS Category:	Energy Information Systems (EIS)	Fault Detection and Diagnostics (FDD)
Used by	Energy managers	Facility operations teams, energy managers, and service providers
Used for	**Portfolio management** • Portfolio key performance indicators (KPIs) / prioritization of properties for improvements • Energy use tracking and opportunity identification (mainly heat maps and load profiles) • Emerging tool for public/occupant communications	**Detailed system analysis** • Reducing Preventative Maintenance Program costs • Improving comfort with zone-level diagnostics • Finding hidden waste and maintaining savings (participants shared that retrocommissioning [RCx]) savings did not persist without MBCx) • Many participants pull whole building meter data into FDD tools through the building automation system (BAS), but few are actively using these data. Their focus has been on using the BAS data with the FDD software.
Typical installation	Whole building energy meters by fuel for large buildings in a portfolio, either with utility-provided interval data or owner-installed meter. Submetering is less prevalent.	Installation focuses on FDD for problem HVAC areas (central plant, air handler units (AHUs), or variable air volume (VAV) terminal boxes.
Common analytics	• Energy use intensity (kBtu/sq ft) • Heat map • Load profile, filtered by day type	• Chiller plant operations and setpoint optimization • Air handlers (simultaneous heating and cooling, economizers, valve leak-by) • Terminal unit operation • Detecting failed sensors
Top measures implemented through the MBCx process *n=33 participants* *Floor area: 74 million sq ft*	**EIS implementation only** Improved HVAC scheduling Share energy information with occupants Adjustment of space temperature setpoints	**EIS + FDD implementation** Improved HVAC scheduling Improve economizer operation Reduce overventilation Reduce simultaneous heating and cooling Reduce VAV box minimum flow Adjustment of space temp setpoints Supply air temperature reset Tune control loops to avoid hunting
Energy Savings* *n=15 participants* *Floor area: 39 million sq ft*	Energy savings (whole building, all fuels) since EMIS installed: Median: 5% ($0.20/sq ft); range: -1.5% to 32% Mean: 10% ($0.39/sq ft) The mean is less representative than median due to the wide range in savings. **Preliminary figures for 15 participants and 414 buildings; to be updated annually. These savings are not specifically attributed to operational improvements, retrofits, or other factors. Therefore, savings may be associated with improvements not related to the EMIS.*	
Cost* *n=9 participants* *Floor area: 50 million sq ft*	Median EMIS base cost (software + installation): $0.04/sq ft; range: $0.004–$0.14/sq ft Median annual labor cost/sq ft: $0.08/sq ft; range: $0.01–$0.14/sq ft Median total first year cost: $0.12/sq ft Median EMIS software recurring cost: $0.01/sq ft; range: $0.0004–$0.03/sq ft **Preliminary figures for 9 participants; to be updated annually. Cost data have been provided in $ and normalized by floor area. Most participants have large portfolios; therefore, the normalized costs reflect these economies of scale. Smaller buildings may have higher cost per square foot.*	

1. Introduction

Buildings are full of hidden energy savings potential that can be uncovered with the right analysis. With sophisticated software to inform and assist in building operations, building owners now are reducing energy and improving operations using building analytics. The Smart Energy Analytics Campaign targets the use of a wide variety of commercially available Energy Management and Information System (EMIS) technologies and ongoing monitoring practices to support data collection and analysis that reveals the most effective energy-saving implementations and strategies as well as research and development needs.

Table 1. Smart Energy Analytics Campaign Quick Facts

Campaign Goals	DOE and LBNL work with private sector partners to understand, advise, and track the functionality, use, cost and benefits of existing or new EMIS in commercial buildings.
Participating Partners	46 organizations representing 2,300 buildings and 185 million square feet (sq ft) gross floor area (as of July 2017)
Participation	Participating partners analyze hourly interval data, perform fault detection using building automation system (BAS) data, and/or implement automated system optimization
Energy and Cost Savings	400 billion Btu/year and $9M/year savings across 15 participants' building portfolios with EMIS installed
Campaign Start Date	Recruitment launch in May 2016, and full Campaign launch in October 2016
New Reports Available	MBCx Plan Template Using EMIS to Identify Top Opportunities for Commercial Building Efficiency
Spring 2017 Recognition	• Largest Portfolio Using EMIS - MGM Resorts International • Energy Performance in a Portfolio - Emory University • Best Practice in the Use of EMIS - Sprint in partnership with CBRE | ESI • Energy Performance in a Single Site - Salt Lake City • Innovation in the Use of EMIS - University of California, Davis

EMIS are the broad and rapidly evolving family of tools that monitor, analyze, and control building energy use and system performance. The Smart Energy Analytics Campaign focuses on these EMIS technologies:

- **Energy information systems (EIS):** An EIS is broadly defined as the software, data acquisition hardware, and communication systems used to store, analyze, and display building energy data. EIS are a subset of EMIS focused on meter-level monitoring (hourly or more frequent).
- **Fault detection and diagnostic (FDD) software:** FDD software automate the process of detecting faults with physical building systems and processes and help to diagnose their potential causes. FDD are a subset of EMIS, focused on system-level monitoring (using building automation system [BAS] data).
- **Automated system optimization (ASO) software:** ASO software continuously analyzes and modifies BAS control settings to optimize heating, ventilation and air conditioner (HVAC) system energy usage while maintaining occupant comfort. These tools both read data from the BAS and automatically send

optimal setpoints back to the BAS to adjust the control parameters, based on data such as submetered energy use and energy price signal.

The data generated from EMIS tools enables building owners to operate their buildings more efficiently and with improved occupant comfort by providing visibility into and analysis of the energy consumed by lighting, space conditioning and ventilation, and other end uses. EMIS tools are used in the monitoring-based commissioning (MBCx) process to organize, present, visualize and analyze the data.

MBCx is defined as the implementation of an ongoing commissioning process with focus on monitoring and analyzing large amounts of data on a continuous basis. MBCx may be used during and after an existing building commissioning (EBCx) project to be sure that energy savings last, and to look for additional opportunities. Based on an EBCx process average whole building energy savings of 16 percent[1], the MBCx process can save up to this level or more over time, mainly through low cost operational improvements.

Figure 1 illustrates the three main elements of MBCx, showing how tools like FDD and EIS are incorporated into the MBCx process.

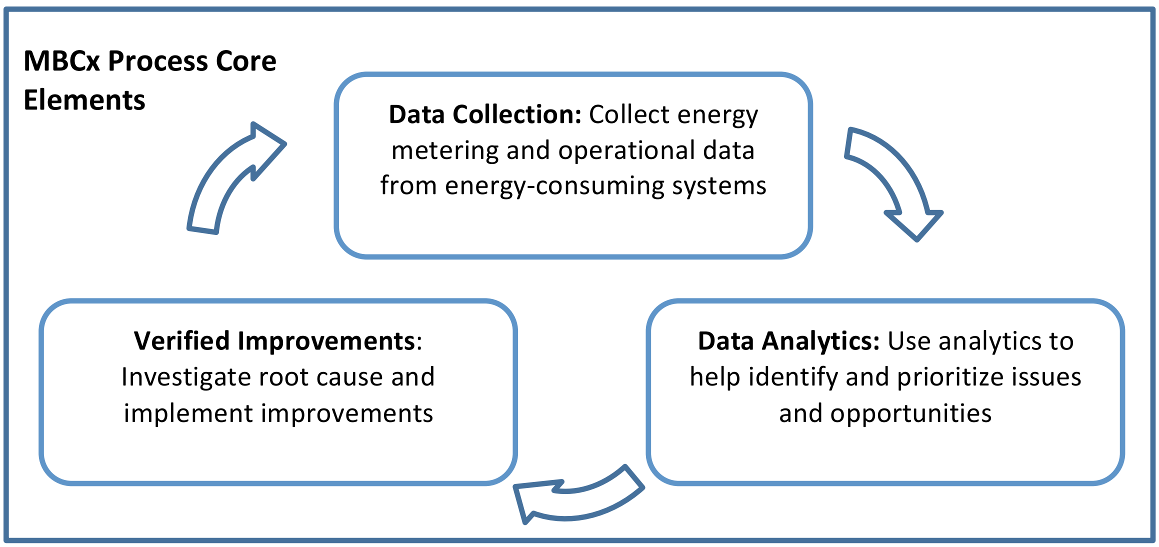

Figure 1. Monitoring-Based Commissioning Process

[1] Mills, E. 2009. "Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse-gas Emissions" http://cx.lbl.gov/2009-assessment.html

2. Campaign Participants

This section summarizes data collected through the campaign based on reporting to date from 74 percent of participants (22 percent of participants have not yet implemented their EMIS, and 4 percent of participants did not report).

2.1 Participant Activities

Current Campaign participation includes 46 private sector organizations representing a total gross floor area of 184,885,000 sq ft, and about 2,300 buildings. Participants are mainly in the office and higher education market sectors, with hospitals and government laboratories also joining (Figure 2). The most common portfolio size is between 1 million and 5 million sq ft (Figure 3).

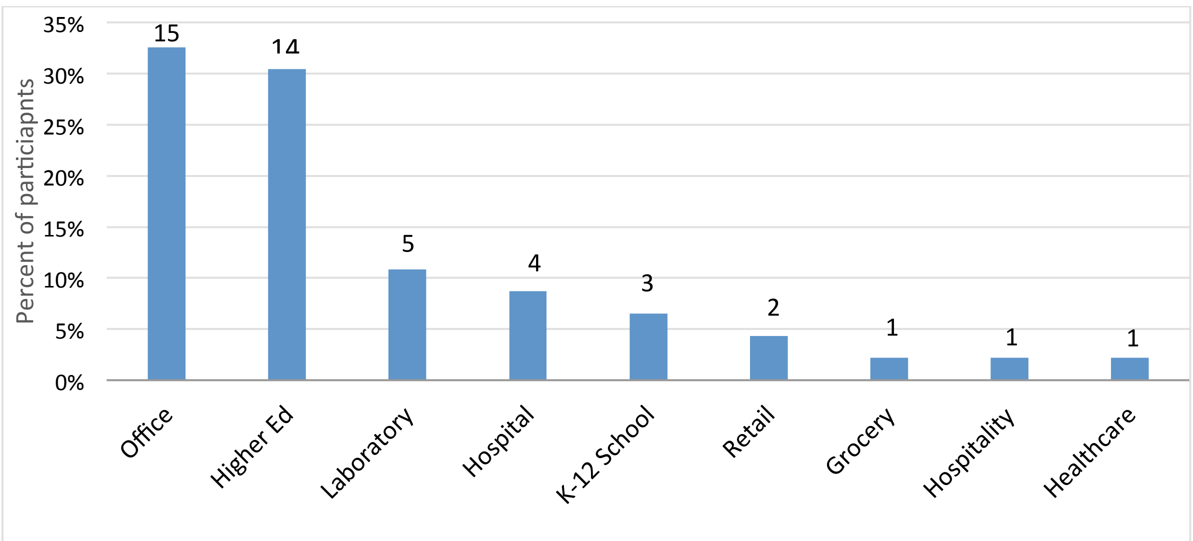

Figure 2. Participants by Primary Market Sector (n = 46)

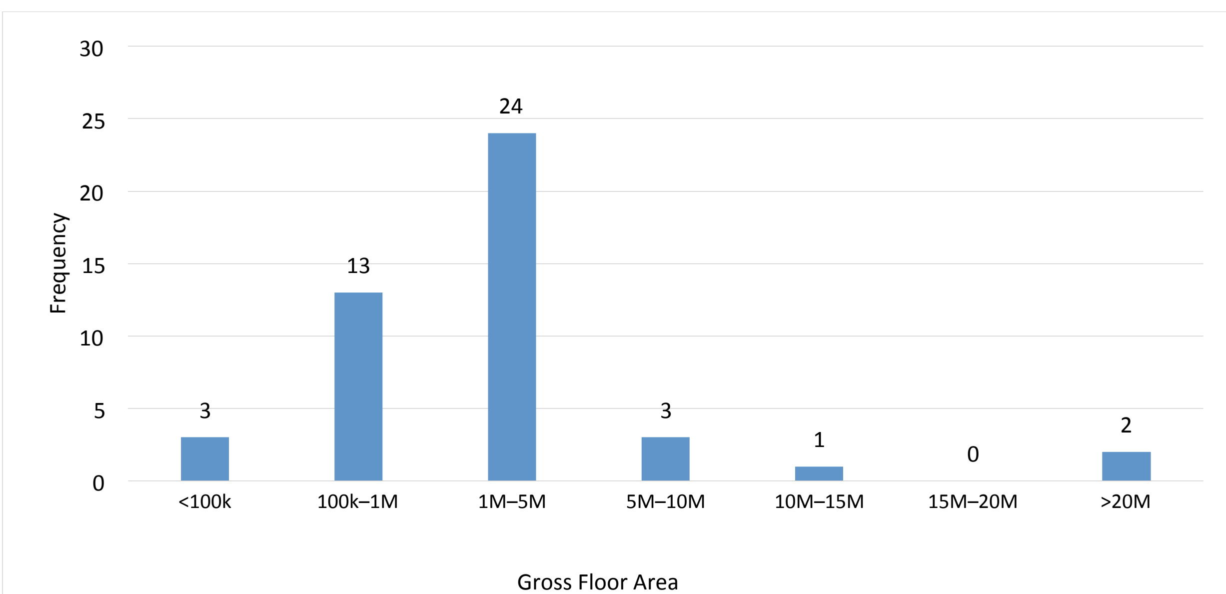

Figure 3. Distribution of Gross Floor Area for Pledged Participants (n = 46)

Large portfolios find benefits and economies of scale in implementing EMIS across their portfolio, including the ability to use EIS to benchmark their portfolio, manage energy use from a single location, and sometimes control building systems remotely using an operations center staffed with analysts.

2.2 Data and Tools

Almost all participants have access or are gaining access to whole building hourly data in addition to their monthly utility bill data, and about 30 percent of participants have submeter data for tenants or other end uses. The most common analysis tools used are the BAS, ENERGY STAR Portfolio Manager, and spreadsheets. Campaign data shows that where EIS and FDD that have been implemented, operators benefit from expanded analysis capabilities, well beyond these common analysis tools. About a quarter of the participants are installing new EMIS during the Campaign, 35 percent are using an existing EMIS, and 40 percent are upgrading their EMIS to deploy in more buildings or add additional functionality. Of those planning to install EMIS, one-third plan to install an EIS, one-third plan to install FDD, and one-third plan to install both EIS and FDD technologies.

Participants implementing EIS, either alone or in conjunction with FDD, are analyzing hourly (or more frequent) interval data, with a total of 63 percent incorporating interval meter data into their EMIS (Figure 4). FDD is gaining momentum as integration of BAS data into the FDD software has improved, with 41 percent of participants implementing FDD as an overlay software to their BAS. Over half of those with FDD analyze whole building meter data in addition to the BAS data. These participants may use FDD software to analyze the BAS data and separate EIS software to analyze the meter data, or they may bring the meter data into the BAS and analyze this data within the FDD software. Participants with both FDD and EIS tended to use the FDD functionality most often within their building operations due to its ability to provide more actionable information. ASO is not yet prevalent with Campaign participants, even though these participants are generally early adopters. One participant is using ASO, and they also have EIS installed.

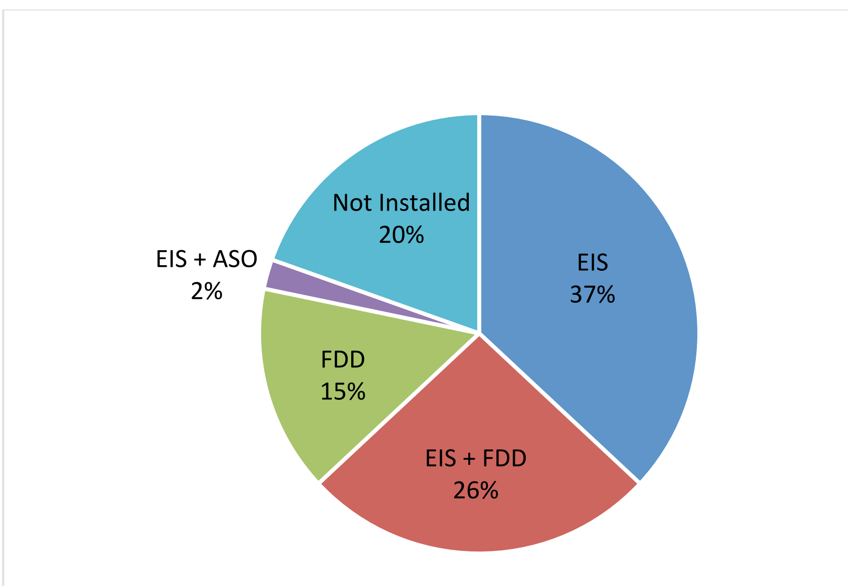

Figure 4. Type of EMIS Installed by Participants

Most participants needed less than six months to install and configure their EMIS. A few participants experienced significant challenges getting meters connected and properly communicating, with multiple years required to get all the issues resolved.

2.3 Energy Management Process

The use of data and software in combination with an overarching defined energy management process is critical in realizing the value of EMIS. Almost all participants have an energy management team mostly made up of facility engineers or technicians and energy managers (Figure 5). The energy managers tend to lead the analysis process and are sometimes supported by a consultant or service contractor. About 30 percent of participants contracted with a service provider to support their MBCx process.

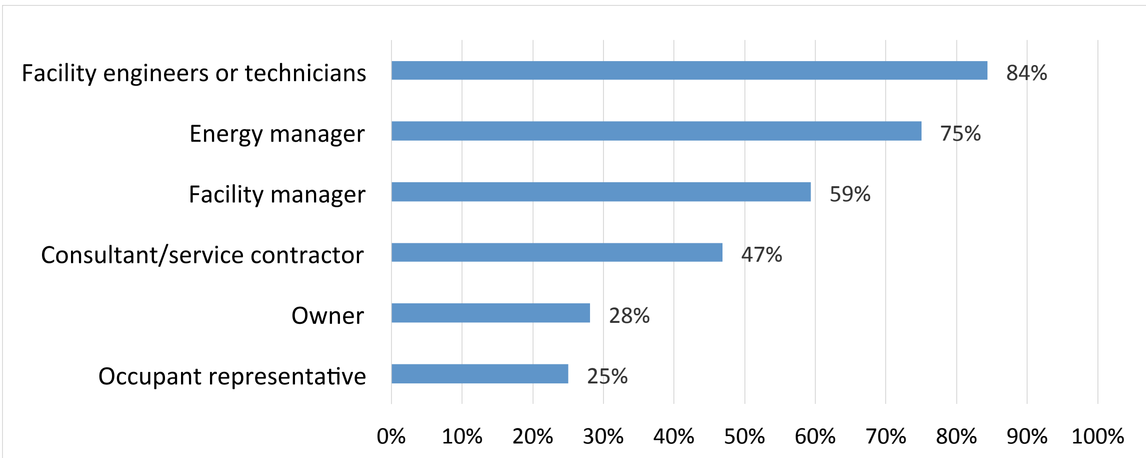

Figure 5. Energy Management Team Members

Most energy management teams are using a periodic performance tracking process (Figure 6) that may not have been as formalized and comprehensive as those implementing monitoring-based commissioning.

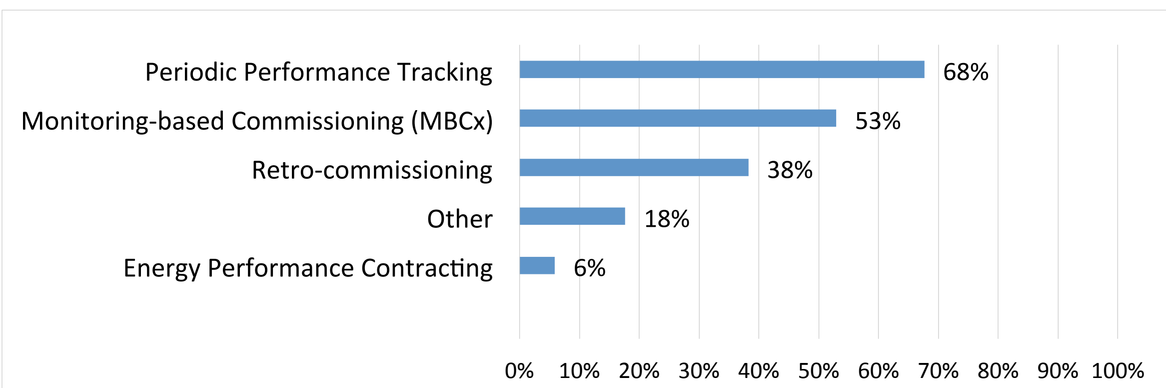

Figure 6. Energy Management Process Implemented

A portion of the participants implementing MBCx provided information on their scope of activities.

- **Common MBCx activities**: in-house review of EMIS analysis and reporting to identify issues, commissioning the EMIS to verify data accuracy and configuration, implementing a management process for taking action to correct issues, and using the EMIS to document energy and/or cost savings

- **Less common MBCx activities**: a program for staff or occupants to recognize energy savings and an EMIS training program to maintain ongoing energy management processes.

An approximately even distribution of participants reviews their EMIS daily, versus weekly or monthly, shown in Figure 7. EMIS type did not have a large impact on frequency of EMIS use. It is somewhat surprising that FDD reports are not reviewed more frequently than the EIS analysis, since attending to specific faults may be a more immediate operational concern than analyzing energy use data. However, reviewing faults takes time, so this may be difficult to perform daily. Also, some faults need time to accrue. The fault is not critical for a single day, but over time energy waste adds up to a level worth investigation. Monthly review of the EIS and FDD results may be driven by preparations for monthly energy team meetings and reporting to management.

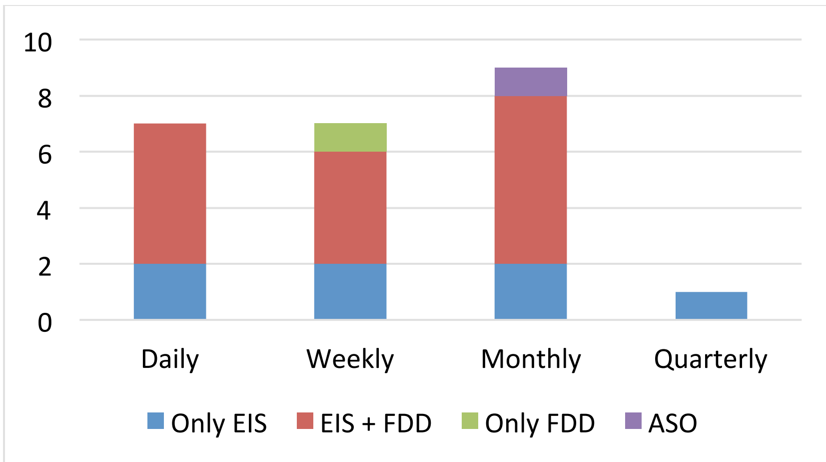

Figure 7. Frequency of EMIS Review by EMIS Type (n = 25)

3. Benefits and Costs

This section reports on the results of data collection around motivation for EMIS, measures implemented using the EMIS, energy savings, and costs. The energy savings and costs are preliminary findings from the participants that have provided this information to date.

3.1 Motivation to Implement EMIS

Energy and cost savings are often a driving factor in the decision to implement an EMIS, as shown in Figure 8.

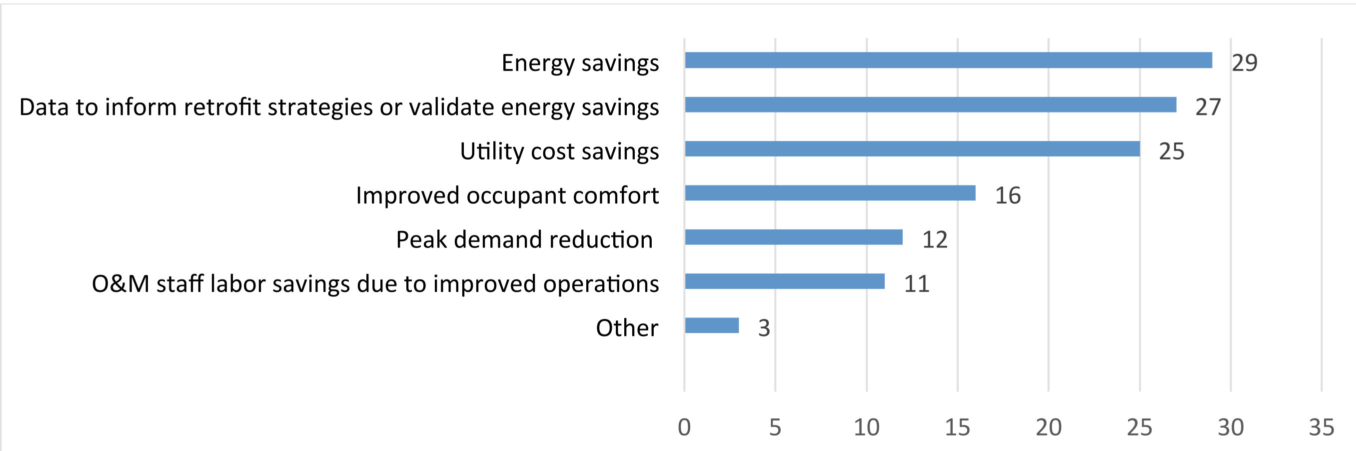

Figure 8. Frequency of benefits of implementing EMIS (participants may select multiple benefits)

Energy savings generally were validated by exporting data and analyzing it outside the EMIS, with the EMIS supporting data acquisition and central storage. The wide range of benefits indicated by participants provides multiple motivations to install an EMIS, and a strong value proposition from multiple perspectives: owners, energy/facility managers, and building operators.

3.2 Top Measures Implemented

Participants were asked to indicate up to 10 most frequently implemented measures in which they utilized the EMIS, from a list of 26 common operational improvement opportunities and noted in Figure 9.

Overall top measures included:

- HVAC scheduling,
- Setpoint and reset schedule changes,
- Economizer improvements and outside air reduction, and
- Fixing control problems such as simultaneous heating and cooling and control loop hunting.

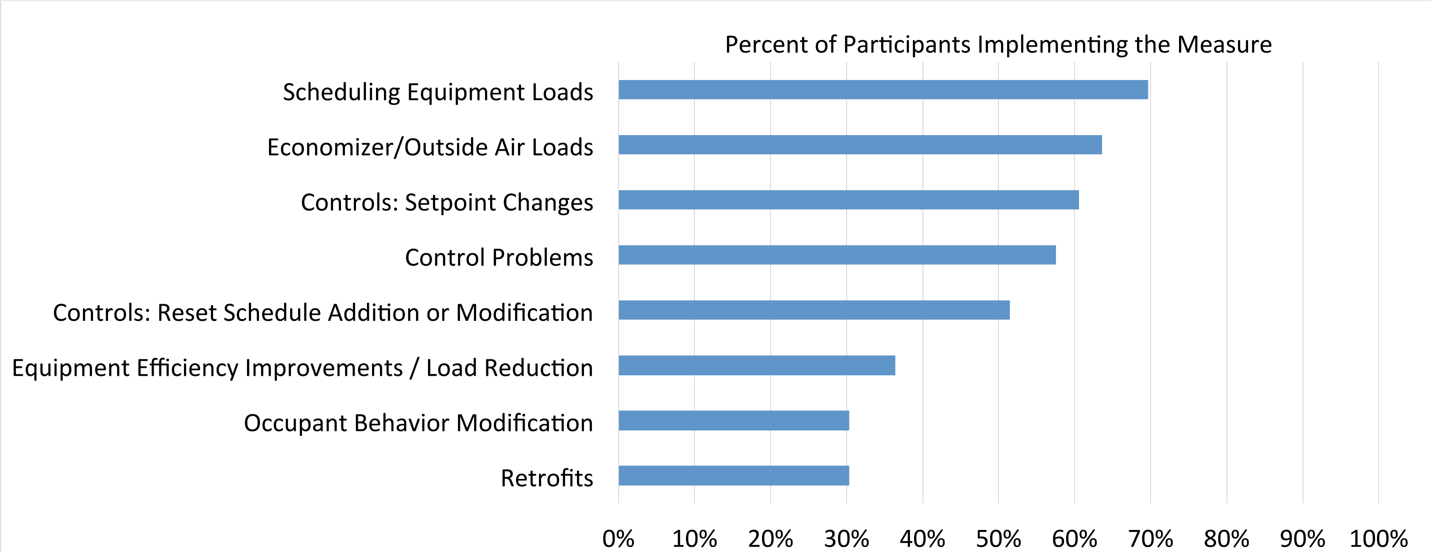

Figure 9. Measures Implemented with EMIS Support

These measures were implemented consistently across all market sectors represented in the current dataset (office, higher education, and laboratory). The higher education sector focused more than other market sectors on occupant behavior through sharing energy information with staff and students, as well as by holding energy savings challenges on campus.

The measures reported as most common to MBCx are also commonly implemented through traditional existing building commissioning, however, use of the EMIS surfaces hidden issues and improves persistence of measure savings. Terminal unit monitoring was an example of being able to evaluate performance cost-effectively and proactively at a broad scale with FDD. Without FDD, operators generally do not have time to perform preventative maintenance on terminal units; operations are checked when there are comfort complaints.

3.3 Energy Savings

To understand energy and cost savings benefits associated with use of EMIS technologies, participants are asked to provide year-over-year trends of energy consumption before and after EMIS implementation and associated annual savings, if available. Fifteen participants submitted the energy data for all or a subset of their buildings (in total 414 buildings, 38 million sq ft). The number of buildings reported by each participant ranged from 1 to 335.

Energy savings since EMIS installation were determined in three ways (Figure 10). Two participants reported savings results gained from interval data analysis tools.[2] Four participants estimated savings using engineering calculations.[3] The energy savings of the other nine participants were calculated by Lawrence Berkeley National Laboratory (LBNL) or the participants using monthly bill analysis,[4] where the pre-EMIS (baseline year) energy

[2] Interval data analysis tool: M&V using Interval data offered as a function within the EMIS, or outside of an EMIS using other software tools such as Universal Translator, ECAM+ M&V module, statistical analysis software, or Excel.

[3] Engineering calculation: Spreadsheet-based calculations based on engineering equations that often utilize temperature or load-based bin analysis.

[4] Monthly bill analysis: Use of the monthly utility bill data to determine energy savings. Weather normalized energy use was used if it is reported.

use was compared to the most recent full year of energy use (2016). Energy cost savings were calculated using national average energy prices.[5]

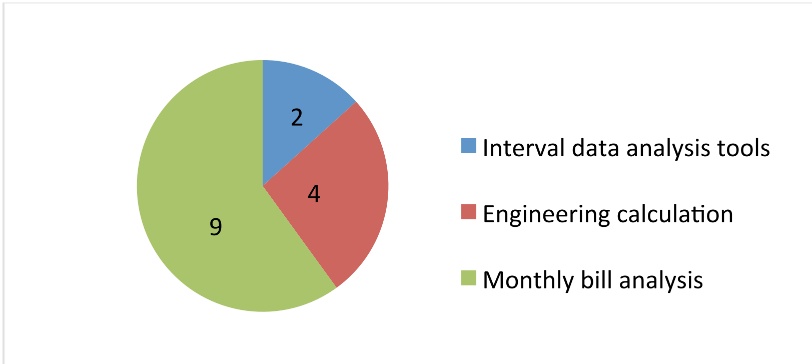

Figure 10. Distribution of energy savings calculation methods (n = 15)

Figure 11 shows the savings results[6] for each participant since the installation of the EMIS, as well as energy cost savings across the same 15 participants. The participant energy savings ranged from -1.5 to 31.8 percent, the median was 5 percent, and the mean was 10 percent. Cost savings ranged from -$0.06 to $1.30/sq ft. The median cost savings was $0.20/sq ft and the mean was $0.39/sq ft. The mean savings is less representative than the median due to the wide range in savings.

Since installing their EMIS, 15 participants have saved a total of 400 billion Btu/year and $9 million/year. These energy savings achievements are attributable to several energy efficiency activities including, but not limited to, use of the EMIS. Section 3.2 reports the top energy saving measures implemented in which the participants utilized the EMIS; additional measures beyond the operational improvements related to EMIS may also have been implemented.

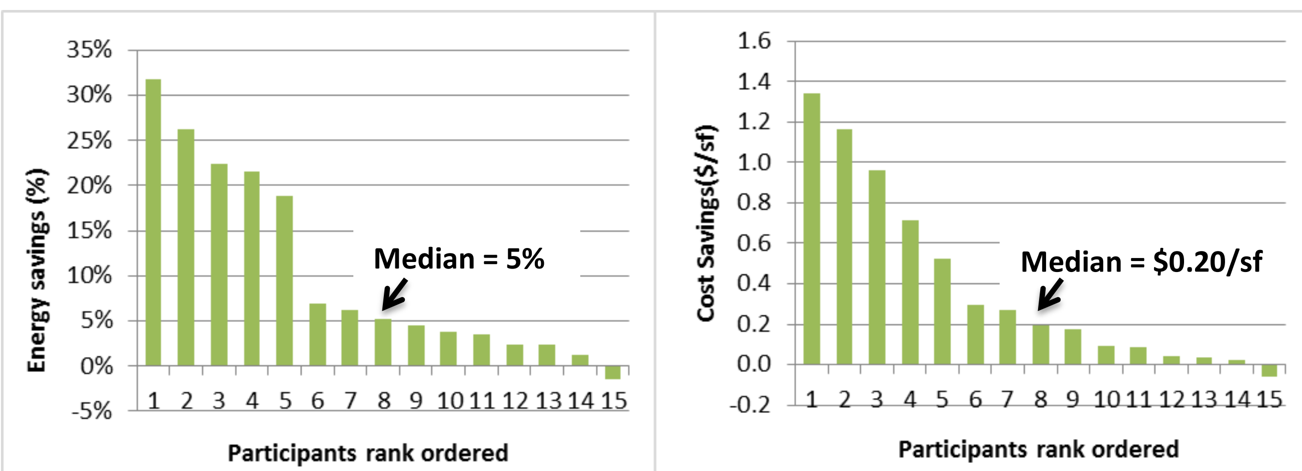

Figure 11. Participant energy savings (left) and cost savings (right) for 15 Campaign participants since EMIS installation

[5] Participant cost savings = Participant energy savings * national average fuel price; the national average fuel price is 0.023$/kBtu, assuming 65 percent of energy consumption in the building is electricity and the rest is natural gas.

[6] Participant energy savings = total energy savings of buildings associated with the participant/total baseline energy of buildings associated.

In addition to total savings, the savings for each year can be plotted, as in Figure 12. Here, each line represents a building, and the y-axis represents percent savings relative to the year before the EMIS installation; the "baseline year." The x-axis represents savings relative to the baseline year, for each year that the EMIS was in place. The red line indicates the median for the cohort. Two participants installed EMIS for three years and the rest installed EMIS for one year. **This plot shows that for the three participants that used EMIS for three years, savings increased over time.** The median first year savings was 5 percent, or $0.18/sq ft, and the mean first year savings was 8 percent, or $0.27/sq ft.

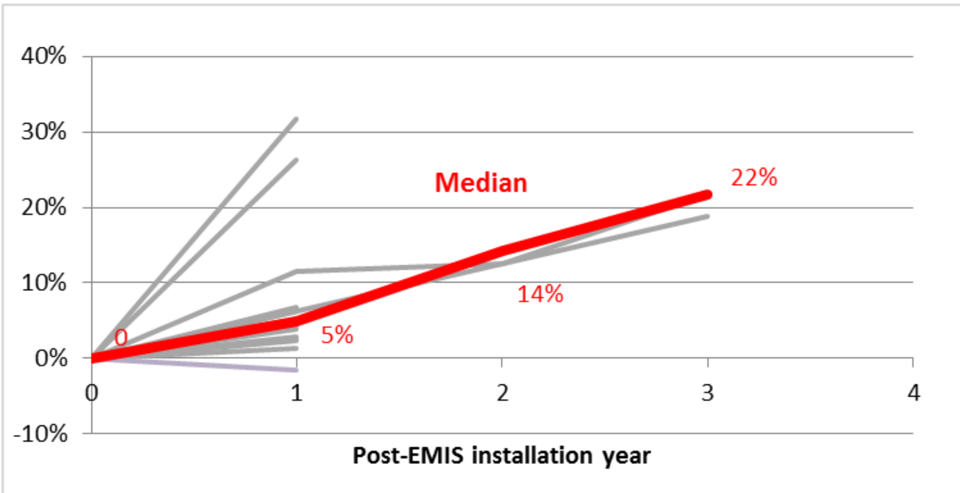

Figure 12. Percent change in participant energy use, relative to the year before EMIS installation; gray lines indicate savings for each of 15 participants, and the red line represents median savings across all participants.

An LBNL study on EIS costs and energy savings in 2016[7] reported 8 percent median savings for nine portfolios, or $0.40/sq ft. This is slightly higher but consistent with the 5 percent median savings for Campaign participants. Many more of the EIS portfolios in the study had implemented EIS for at least three years, compared to only three participants to date in the Campaign. Through Campaign engagement, change in energy use relative to a pre-EMIS baseline will be tracked. We expect the overall savings to increase over time, and since many of the Campaign participants have installed FDD software in addition to EIS, the energy savings from participants may ultimately be higher than the EIS study.

3.4 Costs

Costs to implement an EMIS and perform MBCx have been gathered from participants in the following categories:

- **Base cost:** Upfront cost for software installation and configuration
- **Annual software cost:** Recurring annual cost for software license or software-as-a-service fees
- **Annual labor cost:** Approximate time spent by in-house staff, consultants, or service contractors reviewing EMIS reports, identifying opportunities for improvement, and implementing measures. Reported to Campaign in average hours spent per month. Cost is determined using $125/hour as average labor rate.

[7] Granderson, J, Lin, G. 2016. Building energy information systems: Synthesis of costs, savings, and best-practice uses. Energy Efficiency 9(6): 1369-1384. http://eis.lbl.gov/pubs/eis-synth-EE.pdf

Cost data were provided by participants in dollars for base cost and annual software cost, and have been normalized by floor area. Most participants have large portfolios; therefore, the normalized costs reflect these economies of scale, with lower cost per square foot than would typically be found for a single building. The median costs from nine participants are as follows (data shown for each participant in figures 13 and 14):

- Base cost: $0.04/sq ft; Annual labor cost: $0.08/sq ft
- First year cost = base cost + annual labor cost = $0.12/sq ft
- Annual recurring software cost: $0.01/sq ft

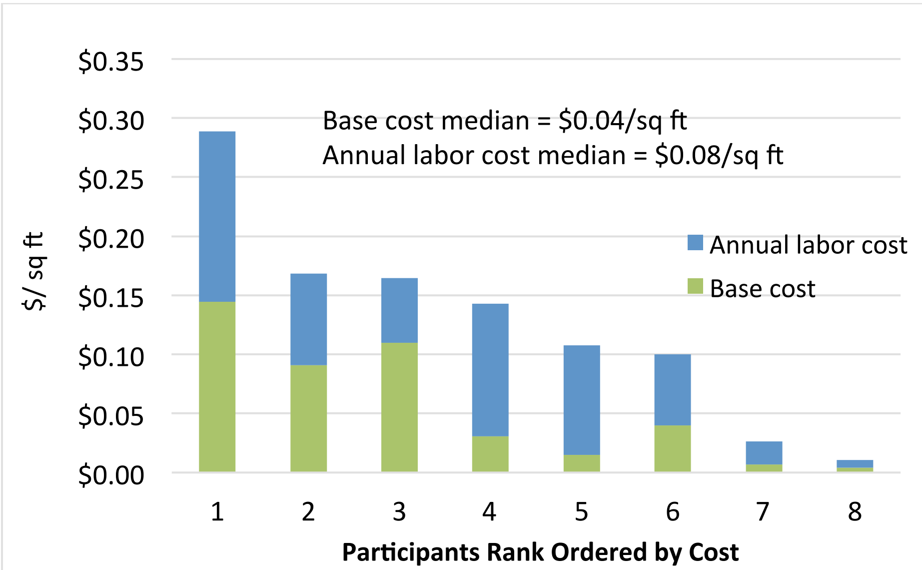

Figure 13. Participant Base Cost and Labor Cost to Implement and Use EMIS

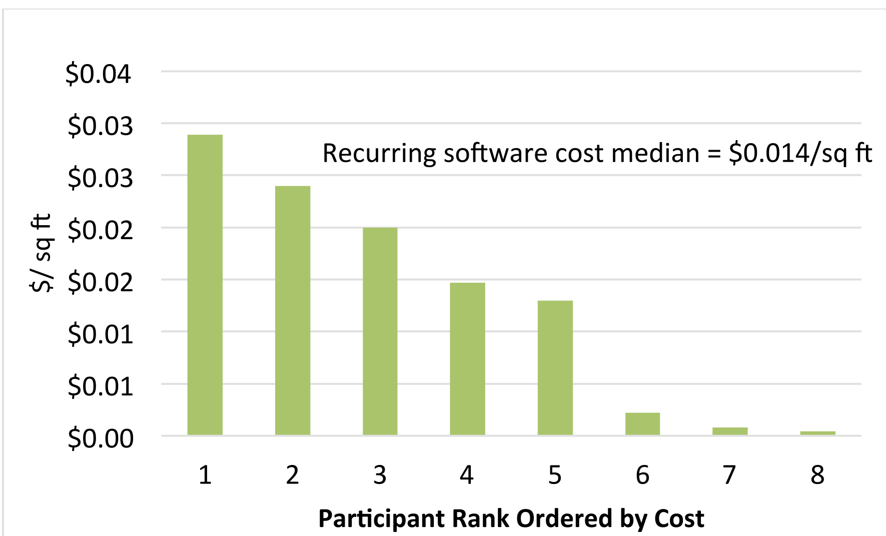

Figure 14. Participant Recurring Software Cost to Use EMIS

While this cost data is preliminary and currently represents a small sample size of nine participants, we observe that recurring EMIS software fees are low. The larger ongoing cost is the time it takes to utilize the

EMIS, which is reflected in the annual labor cost. The high end of the labor cost is reported from sites in their first year of FDD installation, during which time many one-time integration and connectivity issues are detected and resolved, as well as the first set of faults which may have existed for some time.

Levels of support from the integrators and vendors in installation and configuration varied widely, from mostly in-house installation by operations staff with a low level of vendor support to full service installation with vendor support to analyze findings. The varying level of support is part of what is driving the wide range of base cost. The largest installations had the lower costs per square foot, which reflects the economies of scale achievable through broad EMIS implementation.

The EIS cost-benefit study[7] reported $0.01/sq ft base software cost and $0.01/sq ft ongoing software cost; however, this study focused on the cost of EIS and did not include FDD costs. Since FDD implementations have more data streams and complexity in implementing diagnostics, it is expected that the costs reported through the Campaign will be higher. Data integration across the BAS and many devices drives the higher base cost.

Gathering cost data across all participants will be a focus for next year's report and will allow for cost analysis by market sector and EMIS type. This additional cost data will provide more conclusive findings on EMIS costs.

4. EMIS Products and MBCx Services

This section offers trends in EMIS product and services delivery, enablers and barriers to implementation, and industry needs gathered through reporting and interaction with participants and supporting partners.

4.1 Trends in Delivery of EMIS Products and Services

EMIS Selection

Given the wide variety of available features, selecting an EMIS can be challenging task. Most Campaign participants knew whether they wanted to start with implementing EIS or FDD. Whether they start with EIS or FDD, almost all participants want to design an EMIS that is flexible for future additions. Some participants wanted as many energy management features in one tool as possible, to avoid multiple software interfaces.

Participants either went through a request for proposals (RFP) process or chose an EMIS based on vendor demos. In either case, there were a variety of different reasons for choosing their vendor; for example, the desire to program the software using in-house labor, ease of implementation within existing maintenance processes, and known use by peers. To date, Campaign participants have implemented 20 EIS products, 7 FDD products, and 1 ASO product.

EMIS Products and Service List

The Campaign team developed a *Find a Product or Service List* which currently contains 44 EIS products, 20 FDD products, and 6 ASO products (8 vendors offer both an EIS product and an FDD product, with multiple products incorporating SkySpark as their FDD engine). This list is a representative snapshot of vendors and providers and is not comprehensive; inclusion does not indicate endorsement by DOE, LBNL, or the University of California. Through the process of developing and maintaining the EMIS Products and Services List, several insights emerged.

- New EMIS tools are continually being developed, with a few vendors consolidating products.
- Complementary data management products are emerging. For many owners, the ability to gather, manage, and store data is a challenge, so data management products that are front-end agnostic are emerging to meet this need. These products may include basic analytics but generally can be thought of as a data platform that includes data acquisition, communications, and storage. Once data are centralized and of consistent quality, owners can utilize the visualization and analytic capability of the data management product, export the data for analysis, or overlay an EMIS as an analytics layer.
- Some EMIS products are being white labeled or embedded in other EMIS products. For example, SkySpark is the analytic engine for a number of other FDD products. The white labeled products are generally combined with the EMIS service provider's ongoing analytic support.
- Some service providers help users project-manage and prioritize diagnostics, using dashboards to communicate and prioritize the top faults after the service provider reviews the complete fault outputs. Where building operations teams are particularly short staffed, the EMIS service provider may act as an extension of the operations team.

Use of EMIS Analytics

The most commonly used metrics available in EIS installations are energy use intensity (EUI, measured in kBtu/sq ft), heat maps, and load profiles with filtering by day type. These metrics are generally used to identify high EUI, scheduling improvements, baseline reduction opportunities, and demand peaks. Almost all participants have whole building energy use metered by fuel type, with hourly electric data available through interval meters. The use of advanced meter-data analytics is emerging. One participant has implemented automated load shape analysis, and four participants use multivariate regression models developed outside of their EMIS for M&V (using hourly or daily interval data). While at least ten EMIS products in the market currently have automated measurement and verification (M&V) capability built-in to their products, the use of this feature has not been widespread by Campaign participants.

In FDD systems, we looked for trends in how organizations prioritized implementation across their HVAC systems. Some FDD installations focused first on assessing central plants, then branched out to air handlers and VAV over time. Other participants focused their FDD systems on VAV systems to monitor hundreds of VAV boxes that they otherwise could not monitor manually. Similarly, some participants implemented a small set of core FDD rules at many buildings and others implemented all possible rules. Those that implemented the entire set of available rules generally worked with a service provider to help filter the top priority faults. Also, owners with experienced in-house teams often received training from the FDD vendor to program and tune the FDD rules on their own.

MBCx Process

Organizations that have installed FDD and are regularly using it have implemented an MBCx process. FDD users were most active in implementing findings when they had support from MBCx service providers in analyzing and prioritizing faults, and a routine process was in place for following up on faults with operations teams. While most FDD software has built-in estimation of the energy cost waste of each fault to use as a means of prioritization, many participants valued the role of MBCx service providers in diagnosing the root cause of faults and providing a top 5-10 measures for action.

Most commonly, once the EMIS was in place and providing benefits, organizations received stable funding for their MBCx process with top management buy-in. In other organizations, even those with robust savings, the cost of MBCx and the EMIS software had to be justified annually. One participant created a detailed business case documenting the degradation of savings from RCx and the resulting benefits of MBCx.[8]

MBCx Service Providers

Currently 33 EMIS service providers are included in the *Find a Product or Service* list on the Campaign website, with about 40 percent of these companies operating in one region of the country. While this list is long and growing, it is representative and not comprehensive; like the product listings, inclusion does not indicate endorsement by DOE, LBNL, or the University of California.

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[8] Gregory, E, *Commissioning and Emory's Sustainable Performance Program*. Facilities Manager, January/February 2015. http://www.appa.org/files/FMArticles/38-431.pdf

MBCx service providers tend to be commissioning firms expanding into MBCx, controls vendors with MBCx service offerings, or EMIS software vendors that also provide services. A compelling evolution in the industry is the expansion of market delivery of FDD through service providers using the tools to provide added value to their customers. This contrasts with earlier models that relied on in-house direct organizational use, and from analysis-as-a-service provided by the FDD vendor. Figure 15 below illustrates the different ways to implement EMIS. The most limited support for in-house staff is installation support from EMIS vendors or service providers. Additional support in prioritizing and reviewing the output of the EMIS can be provided by EMIS vendors or MBCx service providers. The highest level of assistance includes on-the-ground implementation support from an MBCx service provider.

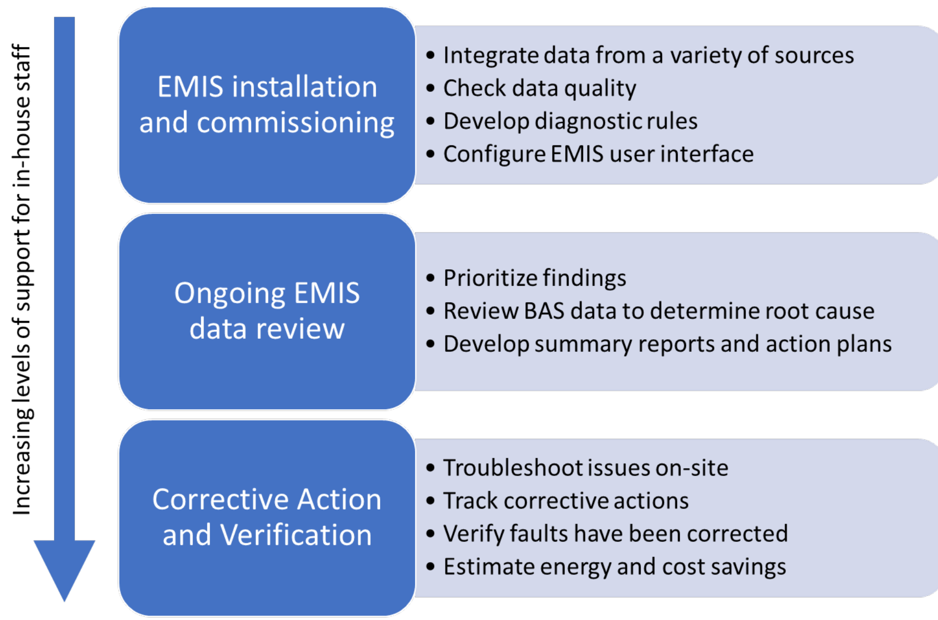

Figure 15. Support options for the ongoing use of EMIS

This expansion in services offers potential to increase access to the technology and its associated benefits for a new class of owners who otherwise may not be using it due to the lack of in-house staff time or expertise to implement an MBCx process.

4.2 Enablers and Barriers

Through the course of technical assistance and qualitative data collection from Campaign partners, we have evaluated and summarized enablers and barriers to successful EMIS software and MBCx process implementation. These are provided in Table 2. Three of the most significant barriers to successful EMIS software and MBCx process implementation include the following:

- Limited information on the true costs and potential savings from using varying degrees of analytics
- Problems integrating data into the EMIS
- Lack of staff time to review the EMIS dashboards and reports, and to investigate and implement findings

Most Campaign participants have successfully made the business case for EMIS and the installed systems that help them improve building operations. Participants that have institutionalized the use of data analytics in their standard meeting and reporting processes are finding their MBCx process to be valuable both from a cost savings and building comfort perspective.

Table 2. Enablers and Barriers to Implementing EMIS and MBCx by Campaign Participants

Category	Enablers	Barriers
EMIS Specification and Selection	• Participants have used DOE's EMIS Procurement Specification as a starting point for an RFP. • Focus RFPs where there is the most interest in using the data (i.e., operations staff may desire FDD for specific faults while energy managers may desire EIS to simplify energy tracking and reporting). • *Find a Product or Service* list on the Campaign website.	• Limited information available on full costs and savings potential hinders the business case for implementing an EMIS. • Users are not clear on which EMIS product features they need. • Lack of clarity on differences between EMIS products • Procurement takes a long time and includes either writing an RFP from scratch or interviewing many vendors.
EMIS Installation and Configuration	• Utility incentives offset costs and support installation and use of EMIS • EMIS service providers support data integration and set-up, then sometimes serve as an extension of the operations team to provide focus on the FDD process. • Commissioning the EMIS installation, including data quality checks and critical sensor calibration. • Data warehousing to provide a single location for all relevant data streams	• Data integration problems include difficulty extracting data from older BAS, disparate data collection systems/naming conventions, and difficulty bringing all the data into a single data architecture. • Data quality problems (gaps in data, incorrect meter readings) • Lack of existing metering in place (cost of adding metering; for instance, when there is a single meter serving a campus).
Analytic Process	• Metrics and diagnostic charts that summarize performance at a glance rather than requiring time-intense manual analysis • Analytics are implemented to address specific operational challenges, rather than implementing all available analytics. • EMIS service providers or EMIS vendors implement an existing FDD rules library	• Users experience data overload instead of gaining actionable insights (this can point to an EMIS configuration problem or an issue with the level of analytics provided) • Difficulty in pinpointing measures/opportunities in the data (especially using meter-level data) • Difficulty finding root causes of problems (i.e., the pumps may be operating at 100% speed all the time but operators need to determine what is causing this fault condition) • Lack of M&V process in place to verify savings
MBCx Organizational Process	• Staff that routinely use EMIS tend to find value; with use across many levels of staff (managers to technicians) • An organization's energy savings goals pinpoint the use of EMIS and reporting features; the need to show persistence of savings drives MBCx. • Standard process for implementing findings; may include integration of EMIS with work order process • Ability to reinvest energy cost savings	• Difficulty maintaining persistence of without robust MBCx process (turns into periodic EBCx where savings degrade after EBCx) • Staff overrides of BAS and desire to operate in manual mode often leads to energy waste.

5. Industry Needs

Through understanding what enabled successful analytics implementation and the barriers that hindered participants (see Table 2), it becomes clear that there are industry needs in the following key areas:

Industry Advancement

- **Data quality and data management:** Accurately and efficiently gathering, communicating, and storing data from various systems, devices, and multiple formats is a common challenge to owners implementing EMIS, and often results in long implementation time frames. The sensor data points in each building are generally created with names that describe different perspectives of the data points, like the data type, content, unit, location, and relationships to other equipment. These names are usually inconsistent among commercial vendors, buildings, and even subsystems in the same building. Thus, interpreting the names of data points to a united format that is readable for FDD tools involves labor intensive efforts. The process of installing FDD software is streamlined when data points are named and tagged in a standardized way. A united metadata schema to understand the relationships between points, as well as establishing standard, consistent naming conventions, are key steps towards streamlining the implementation of FDD tools.

- **Broad functionality for EMIS:** Meeting diverse user needs (i.e., data management, benchmarking, utility bill management, energy analytics, system analytics, automated system optimization, fault prioritization, and project tracking) with one EMIS vendor is a challenge. There is the potential for tool partnerships to meet this need, or the industry may expand tool capability or consolidate tools to provide more comprehensive solutions.

- **Incentives to spur market growth:** Utility incentive programs can offset the base costs of EMIS and set up a reporting stream that allows the program to document persistence of savings. Utilities are in a position to use MBCx programs to engage with customers on an ongoing basis and support operational improvements over time, however there are very few such programs currently available to owners.

Owner Support

- **EIS/meter data analytics:** Organizations need more guidance in how to use meter data to gain diagnostic value. Campaign participants have shared that it is difficult to create energy dashboards that meet needs of varying user groups because they are not sure what to put on the dashboards or how set up the analytics to direct user groups to savings opportunities. The Campaign is providing technical support to participants that wish to tailor their EIS dashboards to meet specific needs.

- **EMIS review and selection:** Determining which EMIS vendors will meet organizational needs and what functionality exists within the vendors' products has been difficult for Campaign participants. There is a hesitancy to broadly distribute EMIS RFPs to many vendors since reviewing responses is time consuming, so organizations tend to select a few vendors to send the RFP. With such a large field of products available, it is difficult to identify this "short list." The Campaign has categorized EMIS vendors at the highest level of functionality (EIS, FDD, ASO) and intentionally has not provided a detailed catalogue of capabilities, as it is difficult to keep an assessment current for so many EMIS vendors that are updating their products over time. Currently, Campaign staff provide guidance about tool functionality, however there is not a standardized way for participants to review EMIS features across all products.

- **Best practices and peer connections:** Campaign participants often note that they do not know how others are implementing EMIS tools and MBCx processes. They have shared a need for support in making the business case for MBCx, developing RFPs for EMIS and/or MBCx, configuring their EMIS, and verifying energy savings. The Campaign's consultation with participants and development of a FDD peer network has proven to be beneficial in sharing lessons learned among those implementing MBCx, with support for making a solid business case and implementing best practices.

MBCx is currently in the early adopter phase, with the most significant growth supported by campus EMIS installations in the higher education market sector and a few MBCx-focused utility programs. Addressing the industry needs outlined above will help expand the industry towards ongoing MBCx processes that achieve lasting operational benefits.

6. Conclusions

With over 185 million sq ft engaged, the high level of participation in the Smart Energy Analytics Campaign points to a growing national trend in the use of analytics in commercial buildings. EIS are becoming common for portfolio owners that want to track energy use centrally and prioritize sites, and FDD is gaining traction as it helps facility teams track the performance of systems. Initial findings from 15 participants with an EMIS installed show median cost savings of $0.20/sq ft and 5 percent annually. Participants have made the business case to install analytics, often without outside funding and incentives because it makes good financial sense.

The data collected show that Campaign partners are utilizing their EMIS to find and fix operational measures at their buildings and portfolios. However, there is a need to improve data integration and management, navigate the many EMIS vendor options, and improve prioritization of fault findings. Partners must dedicate adequate staff time to review the analytics and address the opportunities found with the support of a growing infrastructure of EMIS vendors and service providers. Technical assistance provided through the Campaign continues to focus on helping organizations move beyond data paralysis to building operations that are continuously informed by analytics.